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Determining Factors Hindering University-Industry Collaboration: An Analysis from the Perspective of Academicians in the Context of Entrepreneurial Science Paradigm

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ABSTRACT

Collaboration with industry is critical for academia to create scientific knowledge and obtain industrial data. In turn, collaboration with universities is crucial for organizations in joint, scientific-based research projects in order to develop solutions for production-sourced problems. Both parties need to be in contact via collaborations with the aim of developing new data, methods and technology. To strengthen mutual collaborations and add value, much more attention from both sides should be paid to this subject. Within this context, there should be greater interest from industrialists and academicians, bureaucracy and government regulations should be revised to stimulate the joint projects, field studies should receive more attention in universities, two-way communication should be built between industrialists and academicians, university-industry collaboration centers should be more effective, and finally, mutual publicity should be increased. In this paper, university-industry collaboration is evaluated from the viewpoint of academics. The main finding in the study is that the academics perceive negative factors in the collaboration process.

Key words: University-industry collaboration, entrepreneurial science, research alliances, knowledge transfer, collaboration centers, logit model

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INTRODUCTION

In terms of university-industry collaboration, Turkey has reached a state of focusing on one area of sensitivity. While there has been an increase in empirical and case studies supporting academic research, the development of university-industry collaboration has been accelerated by both government laws developed to create collaboration and industries' significantly accelerating need for scientific knowledge to be competitive at the national and international levels. Similarly, at a national level, newly emerging civil organizations (e.g., university and industry collaboration centers platform) have the potential to bring together many universities and foster collaboration; this common intellect will contribute significantly to future of university-industry collaboration**.** Despite this, Turkish university-industry collaboration has not yet developed as much as desired (Erdoğan, 2009; Akıllı, 2009; Göker, 2008). Observing the slow rate of development, the protocols and basic principles of the general framework of collaboration derived from legal regulations and the models being developed in academia (see also Odabaşı et al. 2009; Maraşlı & Akova, 2009) will more clearly define the format of the collaborations over time. However, some writers have stated that the nature of the formal interaction of universities and industry may change according to situational conditions, and different methods and rules may be applied in the practice of collaboration (Carayol, 2003). Both for Turkey and the rest of the world, it can be said that the level of *formalization* of university-industry interactions is increasing.

When evaluating the relationships of universities with their environment, the basic assumption of system theory (Koçel, 1998) should be considered. In this context, each of the universities is an *open system*, and because of this, the effects of external environmental factors should be emphasized as much if not more than internal dynamics. Therefore, within the framework of a systems approach to academic organizations, there will be continuous and regular input-output interactions with the external environment (Ataman, 2001). In essence, the universities producing scientific knowledge and a skilled workforce are creating joint work platforms together with public institutions, civil organizations, domestic and foreign universities, as well as, in particular, private sector companies with different disciplines. Industrial enterprises are perhaps the most critical external factors predicted by the system theory that directly affect the power of the universities to produce knowledge.

The 'collaboration' arising between universities and industry has different meanings for both parties. When collaboration is realized, academicians reach the knowledge in practice, integrate that information into the higher education system as ‘research data’ and obtain funds for research or find sponsors (Carayol, 2003). In a study of university-industry collaboration, it was stated that the primary aim of academicians was to discover scientific knowledge using new and different applications, whereas financial profit and procuring funds for existing or future research were of secondary importance (Turk-Bicakci & Brint, 2005). In another study of 100 academicians, it was stated that the goals driving collaboration were mainly to provide research funding, to provide funds for laboratory equipment, to gain a practical perspective on academic research and to test theories (Lee, 2000). From this starting point, by broadening relationships with the industrial sector, universities received greater research funding and had the opportunity to strengthen their established academic image. Therefore, applied science has become more important in universities (Turk-Bicakci & Brint, 2005; Siegel et al., 2004). From the industry standpoint, there has been a shift toward the acquisition of knowledge with an academic base, which can then be transformed into production and, in turn, will place industries above the competition (Hagedoorn, Link & Vonortas, 2000), encourage growth, decrease costs, improve the organization’s image, increase the learning capacity of the organization (Ryan, 2006) and develop the firm’s human capital (Bruneel, D’Este & Salter, 2010; Mead et al., 1999).

According to enterprises, the level of success of university-industry collaboration is evaluated by the measurement of business financial acquisitions and the rate of transfer of new scientific-based knowledge and technology that contributes to the work results. The expectations from the collaboration projects are oriented to the development of systems that will continue to increase the autonomy on organizational processes (Siegel et al., 2004). When the potential to provide mutual benefit is considered in successful collaborations, findings from various scientific research studies confirm several scientific characteristics that have had positive effects on businesses, including increased sales volume, the potential for further research oriented toward increased productivity and the increased granting of patents (Cohen, Nelson & Walsh, 2002; Fontana, Geuna & Matt, 2006). When the situation is evaluated from a long-term view, it is clear that the collaboration in question supports the process of *mutual learning* (Bjerregaard, 2009).

Collaboration between universities and the industrial sector has intensified in certain fields, such as staff training and consultancy services or R&D-based research projects. These areas in particular have become the most frequent domains for university-industry collaboration. Additionally, other areas of collaboration can be observed, including the opportunity for university students to have work experience and for graduate or post-graduate projects in various disciplines to be conducted together with industry (Mead et al., 1999), the chance for industrialists to contribute to graduate and post-graduate educational programs and the option for private sector organizations to provide data for scientific research directly to academic staff.

This paper specifically examines the barrier factors encountered in university-industry collaborations from the viewpoint of academicians. The factors that have been assumed to have been the source of barriers in university-industry collaborations from an academician's perspective have been included in the study on the basis of eight criteria: lack of interest from industrialists and academicians, bureaucracy, remoteness of field studies, insufficient publicity, lack of communication, ineffective legal regulations, ineffective university-industry collaboration centers and previous bad experiences.

From the academic dimension, the field of university-industry collaboration in Turkey has not yet become widely studied. While the main theme of university-industry collaboration is primarily given more attention in post-graduate and doctorate theses, academicians do not give it enough importance in articles of scientific study. The situation is not any different when looking at conference papers. Although the 'University-Industry Collaboration National Congress' has made an important contribution to the field in the last four years, the number of scientific articles of empirical content are fewer than those found in the foreign research literature. Therefore, this study aims to emphasize the importance of collaborations in encouraging scientific studies in related literature in Turkey. The majority of published research in Turkey focuses on the industry viewpoint; there are few published scientific studies on university-industry collaboration from the academician's perspective. Therefore, this study can make a contribution to the literature by presenting the perceptions of academicians. This study is also useful for industrialists to learn what academicians think about the subject so that both sides in university-industry collaboration can achieve a better understanding of each other and the academician's viewpoint can be included when resolving problems that arise.

At the first stage of the theoretical framework of this study is the university-industry collaboration formalization. There exists the potential for research at an academic level to establish the perspectives of the industrialist and the academician on the subject, and possible areas of collaboration are defined between industry and universities. At the second stage of the theoretical framework, the *entrepreneur* identity of the university-industry collaboration appears, and the phases of the entrepreneurial academic paradigm and the process of industrializing scientific knowledge are discussed. The third and final part is the evaluation of the factors affecting university-industry collaboration. The applied section of the study includes the methodology used, the data collection process, the econometric analysis results, the conclusion and suggestions for future research.

Entrepreneurial Academic Paradigm

With the transition to a knowledge-based economic structure and the innovation movement that started in the 1990s, universities began to give more importance to organizations pioneering local and national development by producing and transferring new knowledge and technology to the industrial sphere (Tether & Tajar, 2008; Shane, 2004; Wright et al., 2008; Bekkers & Freitas, 2008). Particularly within the changing technology, there have been increased industrial applications of *science-dependent* nano-technology, micro-electronic technology and bio-technology (Baba, Shichijo & Sedita, 2009; Bekkers & Freitas, 2008). The resulting effect of these types of applications in many sectors (e.g., pharmacology and chemicals) has been the growth of the organizational structure coupled with an emerging need for institutionalization, an increased diversity of products and the continual development of processes and efforts for improvement. These factors have made it necessary to establish links with universities to solve organizational problems. While supporting the discovery of new knowledge, the link established between universities and industries yields a significant transformation. The transformation in question can be explained by the concepts of *knowledge industrialization* and *knowledge capitalization* (Eom & Lee, 2010; Crespo & Dridi, 2007). The increasingly widespread perspectives of 'Entrepreneurial Science,' 'Entrepreneurial University' and 'Entrepreneurial Scientist' show the changing nature of the universities' mission and organizational behavior in an educational and research dimension (Etzkowitz et al., 2000; Boardman, 2009). With regards to the entrepreneurship of science, steps taken to industrialize scientific knowledge date back to the 19th century, when academicians from Harvard and MIT wrote the business plans for various companies, managed their funds and supported the employment process (Etzkowitz, 1998).

This new role of 'entrepreneurship' for academia has had a profound effect on the mission of universities with respect to education and the research direction of each higher education institution. The academic mission (traditional education and research) has contributed to the broadening form establishing collaborations in scientific research in various disciplines with regards to general economic and social development (Crespo & Dridi, 2007). Although the rate of change seems to be slow, the change continues. In a study by Etzkowitz et al. (2000), an evaluation was made of the four separate stages of the evolution of an entrepreneurial academic paradigm of a traditional university.

Internal Change

At this stage, the universities re-define the traditional academic duties and widen their scope. In particular, the educational function of academia is changing through the direction of research, methodology development and the questioning of current knowledge. This internal change is triggered by the direction of newly-acquired practical knowledge. For example, faculty members create the opportunity for students to have work experience in firms, and this allows for academic information to be obtained from testing in manufacturing companies. Thus, organic links have been established between academic organizations and firms. The effect of the expanding role of academia in the field of innovation is that academic knowledge has begun to be integrated into industrial life. New rules created in the process of collaboration facilitate the re-formulation of internal processes towards a new 'entrepreneurial academic paradigm' of the universities. However, this transition has its downside, which will be discussed later in this study.

Interaction Between Institutions

At this stage, the government has introduced various regulations on the subject of university-industry collaboration. To develop university-industry collaboration, the legal adjustments have attempted to abolish the conditions of unfair competition and establish relationships between academic and private sector organizations on a clearer legal base. The Cooperative Research and Development Agreement (CRADA) in America is an example. These kinds of agreements encourage collaboration of more concrete projects, allow for the creation of networks between institutions, and lay the foundation for easier access to research funding. The legislations of university-industry collaboration development centers and laws supporting R&D activities, which relate to technology development regions, can be seen as an example of collaboration-based legal regulations in Turkey.

Interface Stage

At this stage in the entrepreneurial academic process, *experts* fulfilling a type of mediating function appear. They manage and develop relationships between universities and the external environment. These experts take on various duties at different levels of management of the university, introduce the university to the external environment, organize seminars and conferences and make collaboration agreements and projects with other academic institutions, companies and public groups. The idea of "interface" in collaborations has come to be more widely accepted as it expands the mentality of the entrepreneurial academic paradigm in universities. University-industry collaboration centers have been revised, with faculty members settling in the role of experts, and collaboration has been shown to operate in an encouraging manner. So the collaborations become more "centralized," and the *interface* approach has strengthened collaborations.

Establishing Organizations

Universities as an entrepreneurial institution, take on certain roles when establishing new organizations. Institutes established to carry out academic research with the aim of providing support to regional development and innovation can be seen as examples of the typology of organizations set up by universities. Central research laboratories, centers of excellence, techno-parks, etc., which have played a significant role in enabling these structures, could be assessed as examples.

The scientists producing knowledge for industrial applications have directly evolved from the scientist profile of science for science's sake in universities. An increasing number of academicians are emphasizing the importance of having external organizations provide support for research projects, acquiring a great proportion of research costs from private or public institutions and transferring knowledge to the industrial sphere (Etzkowitz, 1998). For example, in the USA, an average of 20-25% of academic projects is financed by industry (Carayol, 2003). In one sense, collaboration with institutions outside of universities has been rendered necessary as a route to procuring external support for scientific research; therefore, universities have reached the stage of being dependent on the outside world for scientific research finance. On the other hand, the exchange of scientific knowledge with industrial organizations has given universities access to a significant amount of funding (Debackere & Veugelers, 2005).

Projects carried out in collaboration with industry not only provide finance but also have a positive effect on the performance of academicians in academic publications and in the number of patents granted (Blumenthal et al., 1986; Bekkers & Freitas, 2008). In contrast, a study by Gulbrandsen & Smeby (2005) observed neither a positive nor negative relationship between the provision of industrial funding and academic publications (Gulbrandsen & Smeby, 2005).

How is the level at which an academic institution displays the characteristics of an entrepreneur determined? To examine the entrepreneurial performance of academic institutions in university-industry interactions and the level of success of collaborations, five evaluation measurements have been defined. These evaluation measurements are of great importance in defining the stages of the entrepreneurial academic process (Crespo & Dridi, 2007). The performance measurements are; i) an increase in the amount of funding provided by industry for academic research development projects; ii) an increase in joint scientific articles by researchers from both the university and industry; iii) an increase in licensing agreements made by the university; iv) an increase in income from licensing agreements obtained by the university; v) an increase in new patents resulting from university-industry collaborations.

On the subject of academic entrepreneurship and the industrialization of scientific knowledge, there has been some criticism from authors such as Feola, Godin, Lariviere, Cassier and Claeys. According to these authors, on the one hand, government policies and stimuli created for university-industry collaborations or the applications of scientific research directed at industrial production strengthen the competitive power of firms. On the other hand, the universities' autonomy is significantly weakened, and their real mission is in danger of being lost. Obtaining research funds from the industry raises concerns that this may result in the university distancing itself from its basic research and education activities (Arvanitis, Kubli & Woerter, 2008). Further, by showing the necessity for revitalizing the economy with new laws for university-industry collaboration and encouragement, the government's actions can be considered as *government intervention* for universities and scientific environments. It has been proposed in another related article that the social sciences receive less financial support for research compared to technical sciences, thus creating *inequality* between these disciplines. According to the Canadian Federal Research Bureau, of 2000 research studies in Canada, 20% were directly related to the social sciences, 45% to the natural sciences and engineering and 35% to the healthcare sciences (Crespo & Dridi, 2007).

Factors Affecting University-Industry Collaboration

The differences between universities and industry, such as aims, culture, bureaucratic structure, and human resources profile (Arvanitis, Kubli & Woerter, 2008), create a variety of problems that will be encountered in the implementation of joint projects (Butcher & Jeffrey, 2005; Philbin, 2008). Despite the diversity of areas of collaboration, there are many reasons why university-industry projects cannot be realized. Therefore, the process remains under the influence of several external and internal factors. At this stage of the study, details are given about factors affecting the collaboration process in a negative or positive way.

Etzkowitz and Leydesdorff (1997) suggested a triple helix model for a local and national innovation system managed by three organizational actors in the collaboration process. The model promised a three-way integration of university, industry and government. The triple helix structure was reported to have achieved a balanced collaboration between the organizations, contributed to the management of healthy growth and created an organizational pressure element oriented toward innovation (Etzkowitz et al., 2000; Geoghean & Pontikakis, 2008). In this model, the government perceived universities as important institutions for economic development and undertaking research for industry. The government also created science and technology policies around this context (Tether & Tajar, 2008).

From the perspective of economic development, universities take the lead in patenting (Wright et al., 2008) and licensing studies, with the government serving as more of an entrepreneur encouraging the universities (Shane, 2004). Indeed, because some sectors, such as pharmacology, chemistry, and bio-technology, are in the *university-dependent* knowledge production, and the majority of information transfer is one-way from universities to industry, the government has ownership of university-industry collaboration (Baba, Shichijo & Sedita, 2009; Debackere & Veugelers, 2005). In order to develop the universities' knowledge and technology capabilities and to direct academic institutions through economic development, the government needs to provide much more support (Butcher & Jeffrey, 2005). The government has allocated significant financial resources to research projects with the aim of setting up research centers and encouraging laboratory studies. The aim of the government is to lighten the financial R&D costs of firms, increase the rate of *innovation* in the field of technology, strengthen national firms' international competitive power and increase information circulation among public institutions, private sector and universities (Hagedoorn, Link & Vonortas, 2000).

The government has created several laws legally defining the framework of collaboration to encourage more universities to create collaboration projects with industry. The relevant regulations provide significant tax reductions for industry and encourage university participation by giving a legal dimension to the relationship. This framework of regulations has provided significant financial advantages to firms. Clearly, in sectors with a concentration in R&D, the costs of R&D are a substantial issue. Thus, setting up technological research projects oin university premises has given organizations the opportunity to reduce the costs of R&D projects. The Technology Development Regions Law encompasses tax advantages for firms. It is thus clear that there are significant production cost benefits to be gained by companies conducting R&D operations in technology development regions. The tax benefits in Turkey are; i) firms' R&D staff and research staff are exempt from income tax until 31/12/2013; ii) income from registered development operations about R&D is exempt from corporation tax until 31/12/2013; iii) the profits of entrepreneurs operating in the region from products produced in the region and services delivered related to system management, data management, internet, mobile telephone and military command application software are exempt from income tax, corporation tax and value added tax.

Despite these encouraging points, some of the laws, principles and procedures put in place to *regulate* government-university-industry interactions have in fact created a certain degree of bureaucracy. Bureaucratic hindrances experienced in the mutual relationships slow down the rate of collaboration and extend the time taken to complete projects. As universities are public institutions, the internal registration procedure following an application often prevents a project from being realized at the speed demanded by industry. The bureaucratic structure of universities seriously slows down the decision-making process.

The rolling capital system is another factor slowing down the development of university-industry collaboration in Turkey. Clearly, the rolling capital system has a negative effect on the costs of collaboration projects. According to the rolling capital system, a faculty member receives only 57% of the earnings gained from a project. The 57% received is then subject to income tax. This situation enforces academicians to select one of two alternatives. The first choice is to run collaboration projects without including the rolling capital system, which then creates an *unregistered economy* in the national economy structure. The second alternative is for the deductions made from academicians to be added to the project cost. This increases the financial burden on the firms, which may then not be able to justify the high cost of working with a university. Because the first alternative is illegal, and the second requires a higher budget, this situation hinders the development of collaboration.

Another important factor in the university-industry collaboration is the *functionality* of the scientific knowledge produced in the university. Asheim and Coenen (2005) named this type of knowledge *analytical knowledge* and stated that it tends to go from universities toward industry. By developing innovative work processes and intensifying R&D focused studies, large-scale institutions (Bjerregaard, 2009; Azagra-Caro, 2007) or businesses within a growth trend (Mohnen & Hoareau, 2003) tend to create a high level of value, seek out functional scientific knowledge and integrate this knowledge into the organization (Fontana, Geuna & Matt, 2006). A company's performance level in a current competitive environment is measured by its ability to obtain and adapt scientific knowledge and become more widespread (Philbin, 2008). From this perspective, these organizations need to acquire knowledge from universities, research institutions, private research companies and consults on relevant topics (Tether, Tajar, 2008).

In the literature, the organization's collaboration possibilities with universities and other public research units have been explained with absorptive capacity and openness. Absorptive capacity is a three-staged management behavior (Cohen & Levinthal, 1990) that, in the context of a learning organization, determines the need for knowledge transfer that will add value from sources outside the institution, assimilates the transferred information and, with the information, discovers new knowledge and turns it into economic work results (Fontana, Geuna & Matt, 2006). High absorption capacity, firm openness and professionalism of the senior management are identified as significant factors in establishing collaboration with universities (Mohen & Hoareau, 2003).

At this point, there are questions of particular importance to be answered. Does the scientific knowledge provided by external sources have the authority to solve industrial problems? Does that scientific knowledge support innovation processes and stimulate development? Is it compatible with industry expectations? Without the possibility of application or adding value to the business, the knowledge is not used by industry. Scientific knowledge that does not make the required contribution seriously hinders university-industry collaboration. If the universities are not creating knowledge to solve industry problems, industry will have less regard for the knowledge provided by the universities. This problem is felt more keenly in European countries and is reported as 'European Paradox' According to the European paradox, despite academic institutions in Europe producing a high level of qualitative and quantitative scientific knowledge, the industrial application remains at a minimal level. The inability of academicians to apply or produce scientific knowledge to support the work in the field and academic staff not giving sufficient importance to field studies weakens in the interaction between universities and industry (Debackere & Veugelers, 2005).

Bozeman et al. (2001) analyzed academic researchers in the framework of 'Scientific and Technical Human Capital.' In this approach, academicians perceived to be well-developed are close to the production systems of industry. The profile of the academician, which is emphasized in this approach, is shown to fulfill an important role in university-industry interaction. Therefore, measures that will be able to offer a solution to university-industry collaboration include: to develop academicians in proximity to production, to support academicians' research projects in application units, to give importance to field studies made by academicians and to allocate significant budgets for applied research.

Another key factor for the success of university-industry collaborations is two-way communication. Research states that the two-way communication mechanism should be structured to allow parties to continue collaborations (Schartinger et al., 2002). Communication between universities and industry has been determined to take the form of including several academic disciplines and several areas of industry. This university-industry interaction has been evaluated in both formal and informal dimensions. In the process of formal interaction, there are four basic forms of establishing dialogue (Butcher & Jeffrey, 2005); i) codification (e.g., scientific publications and patents); ii) cooperatives (e.g., joint enterprises and workforce exchange); iii) meetings and internet networks; iv) agreements (e.g., license agreements and collaboration contracts).

University-industry interaction in formal interaction channels were evaluated by Debackere and Veugelers (2005) in four categories; i) formal channels established with academic institutions by new companies that have a technology-intensive production process; ii) joint enterprise projects that involve business and scientific environments; iii) consultancy services supported by agreements; iv) other (collaboration with graduate students, training, systematic personnel exchanges between academic institutions and businesses).

In the dimension of informal communication, 'social' interaction is realized at a personal level between the parties by factors such as shared work areas, being in the same project group, and setting up social networking sites on the internet. Relative to the formal channels, informal channels of communication forge stronger links between parties with a higher frequency of communication. In a study of American manufacturing companies by Link and Bauer (1989), 90% of collaborations between institutions were carried out through informal relationships (Hagedoorn, Link & Vonortas, 2000). Additionally, from the research findings of Yli-Renko et al. (2001), it was determined that the social dialogue between institutions had positive effects on knowledge acquisition and the process of adaptation to the firm. It has been seen that in interactions at an informal level, information exchange acts as a catalyst and encourages agreements to be implemented at the formal level in the future (Debackere & Veugelers, 2005; Bercovitz & Feldman, 2007).

For a strong and sustainable interaction, mutual *trust* is important (Bjerregaard, 2009; Philbin, 2008). Universities are seen as reliable knowledge suppliers from the industry's point of view (Mohnen & Hoareau, 2003). In particular, in areas such as patents and designs, in which confidentiality is a priority, universities have greater confidence in firms. When evaluated in this way, as far as the quality and functionality of scientific knowledge produced in universities is concerned, confidentiality and researcher reliability influence university-industry collaboration. Trust, which is important for the success of current collaboration, is even more important as a guarantee for the possibility of future collaboration. In this sense, trust goes beyond being a form of behavior to being a significant factor providing psychological comfort to both sides (Plewa & Quester, 2007).

One of the biggest problems experienced in mutual interaction is that each side does not clearly know the possibilities and capabilities of the other. A study by Kaymaz, Çiftçioğlu and Acar (2010) stated that 80% of industrialists did not know enough about university facilities. Other research conducted by Bozkurt & Aytaç (1996) indicated that 36% of industrialists included in the research knew little about the universities' activities, and they therefore did not realize any collaboration project with the universities. Thus, industrialists should be informed about universities' internal activities, such as seminars, conferences, scientific study disciplines, the study fields of faculty members, future scientific projects and student profiles, to speed up the decision-making process and to establish collaboration with the universities. The universities do not make themselves well known, and this dominant, introverted tradition of education and research has a negative effect on relationships with industry (Arslan et al., 2009). For example, at Uludağ University, the University Industry

Collaboration Development Application and Research Center website presents information for the industrialist on which topics faculty members can provide training, consultancy and carry out research projects. Using this information, industrialists are able to know from which disciplines, on which topics and from which faculty members of Uludağ University they will be able to obtain support (Kaymaz, Çiftçioğlu & Acar, 2010). Therefore, to raise the awareness level, universities should increase their self-promotion and information-sharing.

Previous collaboration experiences and the level of success influence decisions about the future of collaborations (Hagedoorn & Achakenraad, 1994). While collaboration that present successful results will encourage the next collaboration project, problems experienced for parties or collaborations that did not reach a result weakens the organization's image and has a possible negative effect on the partnership. However, bad collaboration experiences have the possibility of supporting the organization's learning process. Experienced problems can directly give rise to using new methods aimed at avoiding the same previous problems. Thus, forming a legal standard agreement and defining more closely the internal functioning mechanism of the joint institutions can have the effect of ensuring the continuous development of the collaboration process (Bruneel, D'Este & Salter, 2010).

The efficiency of the university-industry collaboration centers is closely related to the success of the joint studies between academic institutions and industry. University-industry collaboration development, application and research centers, R&D laboratories, techno-parks (Kökocak, 2006), technology transfer offices (Kızıltaş, 2009), centers of excellence, and information licensing offices are important structures for building bridges between universities and industry. In Turkey, in the defined government policy for the science and technology development, apart from the activities of institutions such as TUBITAK, KOSGEB and TTGV, structures established at the management level tied to the rectorship on university campuses contributing to the creation of science and technology are not efficiently managed (Yıldız, 2007). Therefore, there has been two main criticism about the efficiency of the university-industry joint research and collaboration centers. i) The centers established with the aim of providing university-industry collaboration have not clearly defined their objectives. These centers are not viewed with sufficient importance by the university management. The centers do not have an independent budget as a faculty or institute does, so planned activities have not been realized. Publicity and information activities need significant financing, and lack of resources prevents activities directed toward industry (Yıldız, 2007); ii) The centers providing university-industry collaboration do not have enough qualified specialist personnel. By recruiting competent personnel, it is possible to raise the quality of service provided to industry in both a qualitative and quantitative manner. If the center administrators are not paid enough for their duties or they are not exempted from their teaching load, then their motivation will be negatively affected (Yıldız, 2007).

A study by Stahler and Tash (1994) indicated several problems, particularly in the functioning of research laboratories. i) most of the time, research laboratories are used for training graduate and post-graduate students, and various courses organized there are viewed as research units. The research laboratories are not perceived as a unit contributing to the university mission to produce new knowledge; ii) central laboratories and centers of excellence have experienced significant problems in purchasing equipment for test-analysis and R&D units, as there have been inadequate funding resources. The tendency of academicians to use the laboratories only for scientific studies have hindered the laboratories in self-financing; iii) the lack of accreditation of research laboratories has been another significant obstacle in collaboration with industry. Products on the international market that have not been tested and analyzed in an accredited laboratory will experience problems. Therefore, industry has a great need for accredited laboratories, particularly for exports. In this respect, it can be said that in Turkey, the majority of laboratories set up outside government, universities or by private entrepreneurs are not accredited; iv) Research laboratories generally perform routine tests and analyses. However, large-scale firms in particular feel that these research units should be weighted toward R&D studies. Therefore, it is necessary to have the required specialist personnel available to manage R&D studies in research laboratories; v) the number of technology parks should be increased at a national level. There are currently 26 technology development parks in Turkey, and this number is not sufficient. However, it is thought that rents for technology parks are high. To raise the level of interest of industrialists in technology parks, the rents must be lowered, and the benefits of R&D studies in technology parks must be thoroughly explained to industry.

Method

In this study, we use the logit model to evaluate university-industry collaboration from the perspective of academicians in the context of an entrepreneurial science paradigm. The logit model is a predictive approach, and the researchers predict a dichotomous outcome. With the assumption of ordinary least squares, this situation, however, requires that the errors follow a logistic distribution instead of their normal distribution. The use of logistic distribution requires an algebraic conversion to arrive at the usual linear regression model:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} \tag{1}$$

where $\mathbf{y}$ is a vector of the dependent variable; $\mathbf{X}$ is a matrix of independent variables; and $\boldsymbol{\beta}$ is a vector of regression coefficients. First, we consider a case where the response y_i is binary, assuming only two values can be coded as 1 and 0. For example, we could define

$$y_i = \begin{cases} 1 & \text{if some outcome event occurs} \\ 0 & \text{otherwise.} \end{cases} \tag{2}$$

where y_i is a realization of the dependent variable $\mathbf{y}$ and takes the values 1 and 0 with probabilities of π_i and $1-\pi_i$, respectively. Assuming the probability π_i depends on a vector of observed covariates, x_i, the simplest method would be to let π_i be a linear function of the covariates:

$$\pi_i = x_i'\beta \,. \tag{3}$$

Equation (3) is a *linear probability model*. Although this model can be estimated using OLS, it has some disadvantages because there is no guarantee that the predicted values will be in the correct range unless complex restrictions are imposed on the coefficients.

For the logit model,

$$\begin{aligned} &\pi_i = \exp\{x_i'\beta\}/1+\exp\{x_i'\beta\} \\ &\Rightarrow \pi_i/1-\pi_i = \exp\{x_i'\beta\} \\ &\Rightarrow \ln(\pi_i/1-\pi_i) = x_i'\beta \end{aligned} \tag{4}$$

where $\pi_i/(1-\pi_i)$ measures the probability that $y=1$ relative to the probability that $y=0$ is an odds ratio.

Since errors in the logit model represent a heteroscedastic structure, weighted least squares (WLS) are more applicable to estimate the equation (4). The resulting estimate is consistent, with its large sample variance given by

$$\operatorname{var}\left(\hat{\beta}\right) = \left(\mathbf{X}'\mathbf{W}\mathbf{X}\right)^{-1} \tag{5}$$

where $\mathbf{W}$ is the matrix of weights.

Because of this complicated algebraic translation, estimated regression coefficients are not as easy to interpret. Estimated coefficients need to be translated to useful coefficients, or an *odds ratio*, using an exponential function. The odds ratios equal to $\exp\left(\hat{\beta}\right)$. If the estimated regression slope is 0.70, then the odds ratio is approximately 2.01. This means the probability that y_i equals 1 is twice as likely because the value of x_i increases by one unit (see Cameron & Trivedi, 2005).

As usual, Wald tests and a confidence interval based on the large sample distribution, which is an approximately standard normal distribution with mean β and a variance-covariance matrix as given in equation (10), can be calculated.

Additionally, a Hosmer and Lemeshov (1989) goodness-of-fit test can be used. The Hosmer-Lemeshow (HL) goodness-of-fit statistic is obtained by calculating the Pearson chi-square statistic from the 2×g table of observed and expected frequencies, where g is the number of groups. The statistic is written as

$$\chi^2_{HL} = \sum_{i=1}^{g} \frac{\left(O_i - N_i\overline{\pi}_i\right)^2}{N_i\overline{\pi}_i\left(1-\overline{\pi}_i\right)} \tag{6}$$

where N_i is the total frequency of subjects in the *i*-th group, O_i the total frequency of event outcomes in the *i*-th group, and $\overline{\pi}_i$ the average estimated probability of an event outcome for the *i*-th group. The *HL* statistic is then compared with a chi-square distribution with (g-2) degrees of freedom. Large values of χ^2_{HL} (and small p-values) indicate a lack of fit with the model.

Data and Empirical Results

This study includes interviews on the subject of university-industry collaboration with academic personnel at Uludağ University in Turkey-Bursa, particularly academic personnel with the potential to carry out industry collaborations. The faculties of Economics and Administrative Sciences, Engineering-Architecture, Agriculture and Veterinary and the Technical Sciences Vocational High School were included in the study. The personnel in those faculties were carefully selected for inclusion as Assistant Professors, Associate Professors or Professors who had the ability to collaborate with industry.

In the research, we used a face-to-face questionnaire method. The questionnaire's content was based on measurements taken from related literature. Thus, the "technical and administrative processes" statement was based on Kuzu and Turhan (2003), and the "research centers, bureaucratic structuring and lack of communication" statement was based Bayrak and Halis (2003). The statement regarding "scientific knowledge responding to the needs of industry" was based on Çengel (2009), Santoro & Chakrabarti (2002), and the statement on "industrialists' awareness of university facilities" from Bozkurt and Aytaç (1996) was taken into consideration. A team was set up to assist with collecting the basic data set for the study. To ensure the robustness of the data, the questionnaire was pre-tested on the team members to see whether any ambiguities existed in the statements. The questionnaire, which contained eight statements, was administered to the participants. The questionnaires' Cronbach Alpha was calculated as value 0.73 and a 5-point Likert scale was used.

The main body of the study consisted of faculty members of Uludağ University, and sample were selected by using *intentional sampling* method. Two basic criteria were considered for the intentional sampling:

i. The university department of the sample must be one where there are disciplines with which industry may want to collaborate.
ii. The titles of the academicians to whom the questionnaire was applied were assumed to have a higher potential for university-industry collaboration.

In this framework, the sample consisted of 170 faculty members, who were assumed to have a high possibility of being involved in university-industry collaboration, from five faculties and one vocational higher education school within Uludağ University.

The participants' profiles, which include gender, tenure, academic department, level of involvement in university-industry collaboration and areas of involvement in university-industry collaboration, are shown in Table 1.

Table 1. Study participants' profile for gender, tenure, academic department, level of involvement in university-industry collaboration and type of involvement in university-industry collaboration.

Gender %	
Female	27.06
Male	72.94
Academic Tenure %	
Up to 5 years	2.35
6-10 yrs	29.41
11-15 yrs	20.59
16-20 yrs	12.35
21 yrs and more	35.29
Academic Department %	
Economics and Administrative Sciences Faculty	21.30 (36 people)
Engineering-Architecture Faculty	26.63 (45 people)
Agriculture Faculty	20.12 (34 people)
Technical Sciences Vocational High School	14.20 (24 people)
Veterinary Faculty	17.75 (30 people)
Level of involvement in collaborations %	
I have been involved in industry collaboration	58.82 (100 people)
I have not been involved in industry collaboration	41.18 (70 people)
Type of involvement in collaborations %	
Only training-based collaboration	15.63
Only consultancy-based collaboration	20.83
Only technical research project-based collaboration	35.42
Training and consultancy-based collaboration	8.33
Training and technical research project-based collaboration	5.21
Consultancy and technical research project-based collaboration	6.25
Training, consultancy and technical research project-based collaboration	8.33

Table 2. Descriptive Statistics

Variables	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8
Lack of interest of industrialists and academicians	3.73	0.66	1.5	5	1.00							
Bureaucracy	4.08	0.98	1	5	0.33	1.00						
Remoteness from field studies	3.31	1.11	1	5	0.39	0.31	1.00					
Insufficient publicity	3.77	0.66	2	5	0.38	0.42	0.31	1.00				
Lack of communication	4.04	0.69	2	5	0.18	0.23	0.33	0.47	1.00			
Ineffective legal regulations	3.88	0.91	2	5	0.13	0.23	0.15	0.15	0.30	1.00		
Ineffective university-industry collaboration centers	3.55	0.88	1	5	0.42	0.11	0.20	0.26	0.27	0.34	1.00	
Previous bad experiences	3.19	0.98	1	5	0.04	0.22	0.22	0.18	0.22	0.23	0.19	1.00

As seen in Table 1, the study participants were 72.94% male. Tenure of more than 10 years was reported by 68.3% of the participants, and there was a balanced distribution among departments for the majority of participants. Within the general distribution, the fact that most participants (40.83%) were from the Engineering-Architecture faculty and the Technical Sciences Vocational High School is significant for the veracity of the study results. As industry members want to collaborate with members of academic institutions for consultancy and research projects, particularly with technical and R&D training content, the Engineering-Architecture faculty and the Technical Sciences Vocational High School represent a higher level of research. As explained in the theoretical section, the field of social sciences does not take as great of a part in joint-study projects as the field of technical sciences. From the industrialists' side, when university-industry collaboration is spoken of, collaboration with technical disciplines generally comes to mind, so the participants must be weighted that way to positively affect the probability of reaching the correct results. It was determined that 58.82% were involved in various forms of university-industry collaboration, and 41.18% have had no involvement. Of those who had been involved, 15.63% were involved only with training; 20.83%, only with consultancy; 35.42%, only with technical research; 8.33%, with training and consultancy; 5.21%, with training and technical research; 6.25%, with consultancy and technical research; and 8.33%, with training, consultancy and technical research.

Table 2 reports the descriptive statistics and correlation matrix of the independent variables in the model. Overall, the level of correlation between the main variables is low, suggesting that multicollinearity is not a serious concern.

Logit regression analysis was used to measure the levels of the academicians' existing perceptions of elements hindering university-industry collaboration. Estimated parameters, heteroscedasticity robust standard errors, marginal significance levels (*p*-values) and odds ratios are presented in Table 3.[1]

Table 3. Logit Model Estimation Results

Dependent variable Academicians participation in University-Industry Collaboration	*Coefficients*	*Standard Errors*	*z*	*p*>|*z*|	*Odds Ratios*
Constant	-3.09	1.40	-2.21	0.03	-
Lack of interest of industrialists and academicians	-0.03	0.01	-2.17	0.03	0.97
Bureaucracy	-0.05	0.02	-2.40	0.01	0.95
Remoteness from field studies	-0.06	0.02	-3.55	0.00	0.94
Insufficient publicity	-0.05	0.03	-1.50	0.13	0.95
Lack of communication	-0.34	0.29	-1.18	0.23	0.71
Ineffective legal regulations	-0.06	0.03	-1.93	0.05	0.94
Ineffective university-industry collaboration centers	-0.25	0.16	-1.58	0.11	0.78
Previous bad experiences	-0.08	0.03	-2.74	0.01	0.93

Table 3 presents the logit model estimation results, where elements of university-industry interaction are perceived by academicians to hinder collaboration, as quantitative evidence. We asked whether the level of interest shown in collaboration was seen as a hindrance or not. The results where sufficient interest was not shown (-0.03, $p \leq 0.05$) in university-industry collaboration reveal that the academicians generally saw this as a hindering element. Looking at the odds ratio (0.97), the issue can be ascribed to a low level of interest, and with the perception that this causes problems, it is possible to reach the conclusion that this has a negative effect on the probability that academicians will participate in joint projects with industry. We tested the hypothesis that experiencing obstructions due to bureaucratic structures negatively affects collaboration. The results confirmed this perception (-0.05, $p \leq 0.05$). The odds ratio (0.95) showed that bureaucratic hindrances negatively affect the probability of academicians participating in university-industry collaboration.

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1 *The calculated HL test statistic* $\chi^2_{HL}=8.51$ *(df=8; p>0.05) indicates that the model's estimates fit the data at an acceptable level.*

The involvement of faculty members in field studies significantly influences the possibility of collaborating with industry. The intensity of field studies aids the production of useful scientific-based industrial knowledge. Conversely, the question of the production of knowledge without the opportunity for it to be applied prevents the inclusion of universities in joint projects with industry. With this perspective, data obtained from the research reveals that academicians are aware of the need to be closely involved in field studies, and they think that not giving the necessary importance to field studies may negatively affect collaboration with industry (-0.06, $p \leq 0.01$). In this framework, the odds ratio (0.94) states that when importance is not given to field studies, the probability of academicians participating in collaborative studies with industry will decrease. The relevance of legal regulations to university-industry collaboration was analyzed, and the data confirmed the academicians' view that the government's legal regulations to encourage university-industry collaboration were not sufficient and thus affected collaboration negatively (-0.06, $p \leq 0.05$). As the government's legal adjustments aimed at developing university-industry collaboration were not effective at the desired level, there was a lower probability of academicians being involved in joint studies with industry (0.94). Therefore, it would not be wrong to say that there is a requirement for the legal infrastructure to encourage university-industry relationships at an effective level.

Another important factor affecting university-industry collaboration is previous experience. Lack of success (unfinished projects, extended time, communication problems between industrialists and academicians and the scientific approach not meeting industrialists' expectations) or having bad experiences negatively affect any future collaboration. The findings reveal that previous bad experiences are viewed by academicians as a factor hindering university-industry interaction (-0.08, $p \leq 0.01$). The odds ratio (0.93) showed that previous bad experiences with collaboration decreased the probability of academicians being involved in joint studies with industry.

The parameters for the other three variables taken into consideration, "insufficient publicity" (-0.05, $p > 0.05$), "lack of communication" (-0.34, $p > 0.05$) and "ineffective university-industry collaboration centers" (-0.25, $p > 0.05$), were not considered statistically significant, were excluded from the analysis and are not evaluated in the following section.

Conclusion and Suggestions

The main finding of this research is that various factors hinder the process of collaboration by academicians. Negative perceptions of academicians are seen in the areas of bureaucracy, subject interests, proximity to field studies, previous experience, government policies, publicity and the functionality of collaboration centers. To eradicate these negative perceptions and show a higher rate of participation by academicians in the collaboration process, it is necessary to make improvements. Removing the elements perceived to hinder university-industry collaboration will make it possible for a greater number of projects to be implemented. Therefore, in this section of the study, suggestions are proposed to remove the factors that create barriers to collaboration.

The first noteworthy finding of this study is that, from the academicians' view, there is the perception of lack of interest in university-industry interaction from both industrialists and academicians. Both sides should be proactive in stimulating collaboration. Industrialists are close to production problems, such as waiting for orders, managing customer relations and seeking new areas for investment, and these are all areas that consume their time on a daily basis. Attempting to create collaboration with universities within this working environment requires the subject for collaboration to be concentrated. In the same way, intensive scientific studies prevent academicians from creating projects with industry. Gathering industrialists and academicians together to establish a dialogue would be a solution for this problem. Therefore, shared meetings, planned visits to firms, networks established among the organizations, regular news bulletins, periodic reports made by academicians and organized websites should be considered more often to enhance university-industry collaborations. It should not be forgotten that the positive benefits from such collaborations would be a measure of success of the joint projects. If the results will add value to both sides, there will be a belief in the need for collaboration, which will encourage a higher rate of joint study areas in the future.

The other important variable in this paper is that the proximity to field studies in university-industry interaction is a significant factor for the desired level of collaborations. The research results indicate the need for a much greater concentration of academicians in field studies. The success of these joint projects depends on the usage of science-based knowledge by the industrialists and the implementation of this knowledge in the production system. Academic institutions need to produce knowledge that can be used in industrial applications, so more academicians should be encouraged to do field studies. Universities have to allocate an adequate budget for joint projects, and industrialists should take the opportunity to commence projects in organizations. Indeed, collaboration protocols should be signed between universities and industrial organizations for applied research, which would then develop organic links with industry. Moreover, projects that have been successfully completed and that have been put into practice may be given attention for academic promotion. Thus, the practices of academicians can be directed to applying research and producing knowledge that can be used by industry.

Another finding of this study is that academicians are not satisfied with the level of government regulation. Bureaucratic obstacles must be removed to accelerate the process of collaboration. From the moment of applying to the university for collaboration, all stages must be scrutinized and justified. Unnecessary documentation must be removed, and decisions should be more quickly made. Also, the university-industry collaboration center administration must have more autonomy. The centers, being an interface between the universities and industry, should have an independent budget. In addition, in the context of legal regulations, the rolling capital system should be revised, and deductions from the projects should be reduced to a satisfactory level for the academicians. The number of technology regions must be increased at the national level, and technology region administrators should be encouraged to create more collaborative projects. The cost advantages presented by techno-parks, particularly in R&D, should be clearly explained to industrialists. Rents for premises must be compatible with industrialists' expectations to achieve a greater number of firms undertaking R&D work in techno-parks.

Clearly, there is an obligation for government, universities and industry to move together to eradicate the perceived barriers to collaborative studies. To achieve success in innovative approaches, these three structures must be interdependent to configure the right collaboration system and to manage a rational process. Despite differing comments from industry, government and university, it is necessary to find common ground to make these revisions within a short time. For example, the government's efforts to encourage innovation with Santez (industry-thesis) projects only focus on the areas of technical sciences, which excludes the social sciences. Academicians working in the field of social sciences are prevented from working within the framework of Santez projects, thus blocking productivity in the field of social sciences in the universities. Another side to this practice is that it restricts firms from strengthening their human capital. These and other similar practices are well intentioned, but all three sides must make adjustments at the same time to find a common way to reform as soon as possible. Each improvement will institutionalize the process of university-industry collaboration to a greater degree.

In this research, factors hindering university-industry collaboration were only considered from the viewpoint of the academicians. However, the study also requires the industry view to make it possible to define whether the factors stated by academicians as obstacles to collaboration are also seen as hindrances by industrialists. To be able to make a general judgement and to more clearly define the problems from both sides, future research should include the views of industrialists.

On the other hand, the sample size was limited, as not all university department disciplines are suited to collaboration with industry. For example, the potential of departments such as the faculty of letters or the faculty of medicine to collaborate with industry is low compared with engineering, architecture and technical sciences. Therefore, the study was conducted with a limited number of faculties and a limited number of academicians. To extend the sample of the study, multiple universities should be included in the research. This will increase the sample size and the reliability of the results.

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