The role of Supporting Factors on Patenting Activities in Emerging Entrepreneurial Universities

Ilker Murat AR, Ankara Yıldırım Beyazıt University, Turkey

Serdal Temel, Ege University, Turkey

Marina Dabic, University of Zagreb, Croatia

Jeremy Howells, University of Kent, UK

Ali Mert, Ege University, Turkey

Rustem Baris Yesilay, Ege University, Turkey

Abstract

Academic patenting has become an important part of the university-industry collaboration and technology transfer but few studies have investigated the institutional frameworks and organizational incentive and support structures in terms of patenting activity. This paper therefore seeks to fill this gap by examining institutional and infrastructure support factors and the impact that they have on university patenting within an emerging economy higher education system, namely Turkey. The analyses uses logit regression analysis to test a set of hypotheses on a large-scale sample of Turkish universities. The findings highlight the positive role of support factors on a university's patenting performance, acting complementarily to the role of Technology Transfer Offices (TTOs). This study will be a guide for managers and practitioners to use support factors complementing the activities of TTOs in emerging economies in increasing patent applications. Finally, this study highlights future research directions and limitations of the research.

Keywords: University-industry links, intellectual property rights, Patents, Academic promotion, technology transfer, Technology Transfer Offices, less-entrepreneurial universities

Introduction

Academic patenting has become an important part of the university-industry collaboration and technology transfer but few studies have investigated the institutional frameworks and organizational incentive and support structures in terms of patenting activity. This study seeks to fill this gap by examining institutional and infrastructure support factors and the impact that they have on university patenting within an emerging economy higher education system, namely Turkey. Thus, knowledge and technology generated by universities and the entrepreneurial ecosystem that has grown up around higher education institutions is an increasingly important element in influencing overall innovation and economic performance [1]–[9], and this is reflected in the growth of university-industry links [10]. University-industry collaboration has been seen as an effective policy instrument to enhance innovation through knowledge exchange that has grown in significance in policy terms [6] [11], [12]. , [13], [14]. Over time universities have an expanded role in science and technology-based economic development [15], [16] that includes not just science and technology, but wider commercial and entrepreneurial mechanisms that mobilize existing campus resources, such as incubation centres, laboratories and other technical infrastructure [17]. As a consequence of the introduction of the Bayh-Dole Act in 1980, the number of patent applications and licensing agreements by United States (US) universities has increased considerably, leading to the generation of new spin-off firms and jobs. The positive impact of the Bayh-Dole Act has attracted the attention of both developed and emerging economies, who have either adopted the Bayh-Dole Act 'as-is' or have developed their own country-specific frameworks for accelerating university patenting that has in turn created innovation and economic growth [18]–[21]. Thus, in Denmark, the Law on University Patenting was enacted, whilst there has been similar legislation introduced in Germany, Norway, Austria, and Finland [22].

Policy actions aimed at enhancing the contributions of universities to the economy have included the creation of university spin-offs to exploit university-originated patents [23], [24]. Universities have implemented a set of actions, such as developing charters and codes of conduct and defining indicators and measures, to make Europe's universities and public research organizations more entrepreneurial [6], [25], [26]. There are also knowledge and skill synergies between academic entrepreneurship and traditional academic responsibilities [27]. Many universities wish to increase their number of inventions, because inventions are a key source of knowledge spillovers [28]–[32] and technology creation for economic growth. In order to effectively utilize the intellectual resources of universities, a new conceptualization of their roles and objectives is required [33].

Universities however choose different methods to contribute to the economy by transferring their know-how and inventions into new products [34], [35]. At an institutional level, individual universities have created a variety of organisational frameworks, such as establishing Technology Transfer Offices (TTOs), Technology Licensing Offices (TLOs) and Intellectual Property Right (IPR) policies, to increase patent generation [30], [36], [37]. TLOs and TTOs remain the most important vehicles for universities to help execute wider knowledge exchange activities [38]. In addition to establishing TTOs, many universities have also adopted other specific policies and measures to encourage researchers to pursue patent applications. As universities have therefore increasingly become involved in economic development, there has been a growth of interest in measuring their impacts on national and regional economies [31], [39]-[43], modelling their third mission outputs [44], and evaluating their innovative networks [45].

Whilst past studies have focused on outcomes and benefits and challenges of university-industry links [11], [16], [28], [30], [46] and a few on motivation factors (see, for example, [47], [48]), as noted earlier few have sought to investigate the institutional frameworks and organizational incentive and support structures in terms of patenting activity as a significant

form of business collaboration and entrepreneurial development. This paper therefore seeks to fill this gap by examining institutional and infrastructure support factors and the impact that they have on university patenting. Extending understanding of how support factors affect patent application can provide a deeper insight leading to the development of new education policies in universities. Thus, this research paper investigates the barriers and enablers to patenting.

Analysis of the effect of support factors on university patents is valuable in addition for two policy reasons. Firstly, universities are working intensively to increase the number of patents generated by university-originated research. This research helps identify new factors that will be useful for these purposes. Secondly, the relationship between support parameters and university patents will insight into the contrasting nature and roles of public and private universities. The other unique side of this research is that is includes data, which belongs to a non-Bay-Dole Act period in Turkey. This also provides a good opportunity for comparison between two periods in Turkey.

The paper proceeds as follows. Section 2 reviews the patent literature in universities and hypotheses, whilst Section 3 provides an overview of the data and methodological framework used in the study. Section 4 then presents the paper's findings, including an analysis of the data, before Section 5 concludes with a discussion of the results.

Theoretical and contextual background

Universities have become increasingly tried to manage of the inventions produced by their staff [21]. As a result of this effort, the concepts of academic patents or university patents have emerged. In this phenomenon, an academic patent is defined as any patent owned by at least one academic scientist while working at the university [49].

Academic patenting has become an important part of university-industry technology transfer as academics increasingly patent and other forms of IPR protection to protect their inventions by [50]. As a mechanism to support this process and further the development of the university as a whole, universities have established TTOs or sought to expand their TTOs' services, focusing in particular on supporting targeted patent services [37], [45], [51]–[57]. Consequently, TTOs in most countries have become an important tool for universities in their efforts to support their knowledge exchange and commercialisation activities and more specifically to increase the number of their patenting [58], [59]. According to a WIPO [60] report, universities, as a percentage of Patent Cooperation Treaty (PCT) applications, had an average annual filing growth of 15% between 1995 and 2014. Nonetheless, applications filed by universities have recently started to be overwhelmingly dominated by China. Thus, for example, the top five Chinese universities, which filed 31,877 applications between 2013 and 2015, compared with the top five universities from Korea (12,730), US (5,590), Japan (3,519), and Germany (2,565). These figures indicate that high-income countries accounted for the vast majority of university patents. In contrast, university patents are far fewer in developing and emerging economics as their national systems of innovation and their higher education system is weakly developed [61] and where non-technical factors, such as culture and regulation remain important institutional barriers [62]. Past patterns and historical trajectories also play a role here. Thus, Shane [63], [64], argues that universities will concentrate on patenting if their previous round of licensing is more effective and if they have more licensing experience.

Earlier studies on academic engagements have shown that individual characteristics play an important role in collaboration with industry and entrepreneurial activities [19]. Furthermore, previous experience and awareness in commercialization, patenting or venture creation increases the likelihood of academics' participation in collaborative activities [65], [66]. Based on these arguments, it is suggested that special support factors targeting individual

characteristic of researchers can also help universities to increase their entrepreneurial outcomes, such as patenting. Although these support mechanisms and new rules and regulations to aid such processes are important in efforts by universities to become more entrepreneurial, it is also important to change academics' behaviour. This change can be accelerated by encouraging academics to create new ideas and by triggering entrepreneurial activity originating from individuals, as opposed to the institutional wide initiatives [67]. This also aligns with Burgelman's [68] model of the corporate entrepreneurial process, which states that if universities wish to accelerate entrepreneurial outputs, then university management should focus on removing current obstacles and on motivating individuals to increase entrepreneurial activities.

In particular the current structures of academic promotion penalizes academic entrepreneurial intentions [69]. [70], [71] also suggest that academic promotion creates strong incentives here and increases research results. Thus, a whole series of studies [37], [72], [73] have identified the lack of academic incentives as a barrier for academic patenting. More specifically Lockett, O'Shea, and Wright [74] identify a key need within universities to create well-established reward mechanisms that will encourage and motivate university researchers for non-academic purposes. Furthermore, Carayol [75] thinks that patenting is a result of strong research involvement whilst a decrease in academic incentives negatively affects patent generation. Lastly, Kauppinen [23] has stated that patent policies not only stimulate the commercialization of research, they also aim to clarify how to distribute rights and responsibilities during the commercialization of research results.

It should be noted here that intellectual property regimes governing university inventions remained quite diverse in Europe at the end of the 1990s [76]-[78]. Many European countries maintained the so-called "Professor's Privilege", which is allowed university researchers to decide whether or not to patent and how to commercialize their discoveries. However, policy changes in recent years in patent law have now allowed the transfer of ownership rights from the inventors to their employers in many countries, ending the "Professor's Privilege" policy, where ownership rights were held by the professor. Many observers have seen this as leading to a decline in patenting rates in a number of European countries, including Finland [79], Norway [80] and Germany [81]. University ownership and a TTO can be superior to a professor privilege system for several reasons. Given the potential of TTOs to act as intermediaries between inventors and potential licensees, it is clear that these structures serve to reduce the uncertainty surrounding university inventions [82].

Many factors have an impact on university patenting. In addition, university patenting is closely related to the participation of academics in innovation and entrepreneurship activities. The type and the nature of these activities are also determined by the university's policies, such as the university's remit, promotional systems and resource capabilities. Furthermore, faculty members get involved in patenting activities to enhance their prestige and reputation and look for new stimuli for their research [18].

In relation to the importance of this issue mentioned above, numerous studies have focused on university patenting activities. Some of these studies [83], [84] presents the statistical evaluation and analysis regarding the annual changes of university patents. Another field of the research in this area is the effect of the acts such as Bayh-Dole Act on university patents which has been studied by [55], [63], [85], [86], [97]. The impact of the university patenting on scientific research efficiency [87]-[90], technology transfer and innovation [91], [92] has also been the subject of researches. Furthermore, many studies [18], [48], [93]-[97] have investigated the determinants of university patents.

The majority of these studies have focused mainly on developed countries. This reveals an important research gap in the literature, which is that such studies focus on practices in

developing countries. The main aim of this research is to determine the supporting factors of the university patents for an emerging country, Turkey. This study also investigates which elements have a mediating effect between supporting factors and patent activity.

Research framing

There is a positive role of university policies in enhancing the university patenting activities [97]-[98]. Academic promotion, as one of the main policies, is an important tool to supporting the academic patent application. This can be achieved in a variety of ways. While one of these is direct support, the much more common is indirect academic promotion. These indirect promotions allow academics to apply for promotion to the grades of Professor and Associate Professor [99]. Many academic inventors already want to receive awards and honours for their patented inventions in addition to royalties paid by licensees [100]. In spite of many measures developed and implemented in order to increase the number of university inventions in Turkey, it is argued here that the main driver of university patenting activity will be those schemes that encourage or motivate researchers to engage entrepreneurial activities, and more specifically in terms of patenting. This leads us to the following hypothesis:

> ***Hypothesis 1 (H_1)*** *Providing credit for patent application in academic promotions increases the propensity of universities' patent applications.*

An awareness of the technology licensing process from idea generation through invention disclosure, patenting, and commercialization is one of the most important factors in universities [30], [101]–[106]. Furthermore, Bercovitz and Feldman [107] argue that the "training/education effect" is an important element for the researcher's decision to pursue invention disclosure and patenting. According to them, the researchers who have a better understating of the technology transfer process more easily adopt the commercialization process. This understanding and awareness can be acquired through different channels including formal training and awareness activities.

According to Govindaraju, Ghapar, and Pandiyan [108] a lack of awareness of IPR in universities, mainly in emerging economies, is the main hindrance to establishing successful patenting and commercialization processes. Thus, most of the universities that wish to increase their entrepreneurial level adopt new methodologies to raise awareness. Some universities incorporate different courses into their curricula; some universities focus more on short-term info days, workshops and seminars [109] for this purpose. In addition to university level measures and new methodologies at governmental level, new legislation was also implemented to increase the awareness level of IPR in universities [110]. A different approach was adopted by Denmark that appointed some researcher managers from outside academia in order to bring a different perspective to the university and to increase awareness of technology transfer and patenting activities [111].

On this basis, the level of IPR awareness is the key point to accelerate patenting and technology commercialization activities. However, there is a difference between the concepts of "awareness" and "knowledge" and here we use the definition of Govindaraju, Ghapar, and Pandiyan [108]. Awareness occurs as a result of informative activities, such as short-term information days and seminars, whereas knowledge requires a theoretical and practical understanding, which can be acquired through formal education. Due to the lack of awareness activities, among both researchers and students IP awareness is low in Turkish universities. According to a report prepared by EBILTEM TTO [112] around 86% of universities do not have any awareness activities in their universities. In addition to that 84% of universities declared that they need education programs on IP issues. These findings show that only a few universities have good awareness level on IP issues whilst the majority have less. Besides

awareness activities about IP issues, only 19% of universities have IP and innovation courses in Turkey. The following two hypotheses are therefore proposed:

> ***Hypothesis 2 (H_2)*** *Universities which have staff in departments that have a better understanding of IPR as a result of awareness activities are more likely to increase their patenting*

> ***Hypothesis 3 (H_3)*** *Universities, which have IPR and innovation courses in their curricula, are more likely to increase their patenting*

According to Amabile, Conti, Coon, Lazenby, and Herron [113] and Baglieri and Cesaroni [114] in order to successfully exploit new knowledge in the form of new goods and services, two conditions need to be satisfied: novelty and use. Technological innovation can be mainly realized through transforming know-how with novelty. The know-how should be protected against competitors, through patent registrations. Academic researchers should therefore not only focus on innovation itself but must also be capable of managing the entire process from ideation through to novelty search, patent application, and commercialization as the final stage. Filing a patent application for an invention that does not fulfil the minimum criteria of novelty and utility wastes money and time and, therefore, there should be a gate to control the flow of inventions to confirm whether they have novelty or not [115]. A common mistake is conducting a novelty search on project outcomes too late in the innovation cycle. It is important to perform the novelty search at the very beginning of project as this helps researchers to assess the novelty of their initial idea and approach. Some universities conduct novelty searches through their TTOs and whilst others assist their researchers and train and educate them how to conduct novelty search themselves before, they start the project. This leads therefore to the following hypothesis:

> ***Hypothesis 4 (H_4)*** *Universities that have mechanisms that support the conducting of novelty searches before a project starts are likely to have more patent applications*

In summary, TTOs, TLOs and other types of university-industry collaboration offices can provide useful services to help universities derive more patents. University administrations have established TTOs in order to reach the further academic patenting. [98] explored the positive role of the TTOs on the involvement in academic patenting. In emerging economies, however, the lack of well-defined internal and external ecosystems and limitations in resources prevent most universities to establish TTOs or other similar interface structures [117] and also this is valid for Turkey. In addition, it can often not be worthwhile to establish such organizations to promote university patents, and there might be an alternative solution until TTOs and other interface organization to use support factors for these purposes can mature.

Data and research methodology

Turkey in context

Turkey is a fast-growing emerging economy that has sought to develop its higher education system and to exploit the commercial and economic development potential of its universities. More especially, it has been trying to increase the number of university-originated inventions and turn them into value-added products on the market. Thus, the first major efforts started in 1994 with the establishment of the Turkish Patent and Trademark Office (TURKPATENT). This was followed by the launch of TUBITAK's University-Industry Joint Research Centres Programme in 1996, with the aim of facilitating long-lasting cooperation between companies and universities through contract research, although this programme did not focus on university inventions and never provided any services for patent filing and commercialization. Although the first effort to accelerate the link between university and industry goes back to the early 1990s, the growth of university patenting was however never a priority until the late

2000s [81]. Subsequent to this, different state-funded grant programs had been launched including techno parks, industrial theses, IPR and Patent Support policies [101]. Although the impact of those programmes introduced after 2002 has not yet been fully studied, preliminary analysis indicates that these programs have been successful. By the end of 2018 there were 5,334 companies operating in techno parks of which 1,080 were start-ups that have generated 2300 patent applications [103].

Establishing TTOs in Turkish universities has been the most important element in developing the higher education system and the development of entrepreneurial universities in Turkey [104]. TUBITAK started to support TTOs in 2013 and by 2017 there were 41 TTOs in Turkey seeking to not only to accelerate technology transfer and university patents, but also assist researchers in contracted research agreements, national and international projects and generation of start-ups. To integrate up all these support schemes and the resulting increase in universities' entrepreneurial skills, the Ministry of Science, Industry and Technology developed a "Public-University-Industry Cooperation Strategy Roadmap" in 2015. Also, significant here is that in Turkey, the minimum criteria for academic promotions have been defined by the Higher Education Council of Turkey (YOK) and are mainly based on quantity and quality of publications. However, universities may decide on additional criteria for academic promotions. These additional criteria can be patent applications, joint research projects with industry and generation of start-up companies. However, these academic incentives are available only at some universities and the impact of these incentives on patenting performance of researcher has not been analysed yet. As a result of the IP policy in Turkey, inventors until 2017 held all IP rights no matter where the IP developed or what the source of finance was (see above). By the introduction of Bay-Dole Act type of rules in 2017, universities instead become the owner of IP for the project that financed by public fund.

The database

Based on the theoretical and empirical research on university patenting, we constructed an online survey to collect data directly from individual departments of Turkish universities. The first part of the survey is dedicated to personal and professional demographic information, such as age, gender, position, department and field of expertise. The second part is consisted of a set of questions on factors influencing the propensity of academics patenting in the universities. The final part involved questions relating to barriers encountered by academics during the patenting process. Responses to questions are given either Yes/No and multiple choice. First the survey sent to 25 head of university department and responses collected. Based on the feedbacks (about length of the survey, clarity of questions, survey timing etc.) the survey revised and finalized for the implementation. During the preparation of the survey, besides review of literature, we also benefited from public debate on the role of the academic on patenting process. We didn't meet any developed and validated scales to be used to measure the corresponding model in emerging economy setting countries.

In order to test the hypotheses generated, a an online survey was implemented in universities in Turkey in 2014. The database was constructed from individual departments of Turkish universities via an online web survey in collaboration with Ege University Science and Technology Centre (EBILTEM-TTO) and the TURKPATENT under the auspices of a project supported by the European Patent Office (EPO).

TURKPATENT distributed an official letter of request for participation to all the Turkish universities (230 universities). So, the research targeted to get response from all universities without sampling them. During this period, one of the researchers followed responses closely and worked in close collaboration with TURKPATENT and provided answers if needed. Responders were head of department/faculty in the universities. In total, 216 universities completed the questionnaire (out of 230), representing an initial response rate of 94%. The

focus of the wider study was on Science, Technology, Engineering and Mathematics (STEM) and STEM related subjects, and whilst it is recognised that non-STEM subjects are of growing importance particularly in more developed economies [117: 419], STEM related subjects still form the most important element of IPR activity within universities, especially from developing and emerging economies. On this basis, only the responses from the Faculties of Engineering, Architecture, Agriculture, Science, Education, and Vocational Schools were included in this study, based on their areas of interest and this leaves 175 universities, representing 76% of the total sample of universities to be used in the analysis.

Measurement of variables

The dependent variable of this research is the *number of universities whose department reported activity of patent application* - a binary indicator of the model that equals 1 if the any department of the university has patent applications, while 0 indicates that the any department of the university has no patent applications. The dependent variable will be named as "*Patent Application*" to make it easier to use in the tables. However, this is not the number of patent application, but the number of universities any of whose department declared patent activity. Independent variables that are defined as support factors are "*Academic Promotion*" "*IPR Awareness,*" "*IPR and Innovation Education,*" and "*Novelty Search.*" The "*TTO Presence*", "*Type of University*" and "*GDP Level of Region*" designation is used as the control variables of the research. If the university has established a TTO, then it equals 1; otherwise 0 and it is 0 for private university and 1 for public university we took GDP per Capita 0 if the GDP Per Capita is less than 17.000 USD (this represents the mean of total GDP of all regions in Turkey; Regional GDP) 1 it is above. Given the binary structure of the dependent variable, logistic regression is employed. The hypothesized research model between the dependent variable and independent variables is provided in Figure 1.

Insert Figure 1 about here

Econometric model

The logistic regression model is the most common one [118], regarding the way it facilitates the substantive interpretation of parameters in bivariate data analyses. Considering the dependent variable PA, let p (PA) be the probability of the University to innovate, p (PA)=Pr [PA=1]. Considering Academic Promotion (AP) explanatory variable, let p(PA|AP) be the probability of the university to apply according to its state of "Academic Promotion", Pr[PA=1|AP={0,1}]. It is assumed that PA follows the binomial distribution, PA~Bin (1,p).

In the regression model, the variable of interest, p (PA), henceforth represented by p, undergoes the transformation known as logistic function and defined as follows (1):

$$logit(p) = log\left(\frac{p}{1-p}\right) \quad (1)$$

Where $\frac{p}{1-p}$ represents the odds of success associated with the patent application. With the use of the logit transformation, while p, being a probability, varies from 0 until 1, the value of the logit function varies from $-\infty$ to $+\infty$.

The logistic regression model is defined as linear in the fixed parameters, $\beta_0, \beta_1, \beta_2, \beta_3$ and β_4 has the following functional form (2):

$$logit(p) = \beta_0 + \beta_1 AP + \beta_2 IPR_A + \beta_3 IPR_{AC} + \beta_4 NS \quad (2)$$

This model can also be re-written in terms of the probability of success (3):

$$p = \frac{\exp(\beta_0 + \beta_1 AP + \beta_2 IPR_A + \beta_3 IPR_{AC} + \beta_4 NS)}{1 + \exp(\beta_0 + \beta_1 AP + \beta_2 IPR_A + \beta_3 IPR_{AC} + \beta_4 NS)} \quad (3)$$

The estimation procedure used in this study is the maximum likelihood procedure. The logit function establishes the connection between the variable answer and the linear predictor. This is the most commonly used connection function because it easily enables the substantive interpretation of the model parameters. Let us then move back one of our explanatory variable AP. The odds of success concerning patent applications have the value exp. (β_1) for each additional unit in the state of academic promotion. Let us suppose that AP=1, if the university has an academic promotion and AP=0, if otherwise. If the estimate of β_1=0.850 this means that the advantage success ratio of the universities having an academic promotion process that rewards patenting activity, compared with those universities without an academic promotion process consists of exp. (0.850) = 2.340. In other words, the patent application advantage is 2.340 bigger in universities having an academic promotion process compared with universities not having one.

Results

Out of 175 universities, 99 of them (57%) reported patent applications when all the percentages of variables in the model have been observed. Just under half (45%) of the responding departments (45) had incentive structures, which provided additional points in the academic promotion exercise if the researcher has a patent application. The share of universities that organise IPR awareness activities on campus was 15% (15), and 13% (12) have IPR and innovation education and courses in the syllabus. The universities who practice some form of 'novelty search' before a research project starts are 23% (23), and the ratio of universities who have a TTO is 38%. The majority of the universities were public universities (89%), which is somewhat above the overall percentage in Turkey of 70%.

Table 1 provides the results of a simple correlation analysis based on these six indicators. Patent application is strongly correlated with four of the hypotheses, but only weakly correlated with TTO presence. Such a weak correlation between university patent applications and TTO presence is unexpected given that it is seen as an important innovation support structure. The reason behind this weak correlation is seen as being the insufficient capacity and relative newness of TTOs and the overall less entrepreneurial orientation of Turkish universities and the higher education system in Turkey [119]. There was found to be no correlation between patent application, university type and the GDP level of region where a university was located.

Insert table 1 about here

Table 2 provides a comparison of means for selected independent variables. The last column of the table shows Z values; the null hypothesis is tested to see if the sample means for the two groups are the same. Large and significant differences were observed in the data. Patent applications are 1.5 times higher in universities that have academic promotion practices than those without, whilst patent applications are 2.4 time higher in universities that have some form of IPR awareness activities. Similarly, patent applications are 2.3 times higher where the university has novelty search routine practices in existence. University patenting is also 1.1 times higher if the university has a TTO, compared with universities that do not have one. Lastly, here university patenting is 0.7 times higher in public universities compared with private universities.

Insert table 2 about here

Table 3 then presents the results of logistic regression to examine the relationship between university patent applications and other defined support factors. It also shows the logit coefficients, and calculated odds ratio including significance level. In the regression model, TTO presence university type and GDP level of region were used as control variables. Control variables were added into the model sequentially in order to see the contribution of each variable to the model. All independent variables in the model specifications are binary variables indicating whether or not the university does, or does not, have particular variables. All regression results demonstrate that the model is very strong (percentages =/>89.95%) and have pseudo R^2 is around 0.09, which confirms the adequacy of the models.

Four sets of models were run, firstly to compare university patent applications with the support factors and, secondly, to include TTO presence in the model as control variables. A third model variation was included by introducing the type of university and finally in the fourth model we added GDP level of region where university locates; then we re-ran the model. Model I in Table 3 reveals that the first variable, academic promotion, has a large, positive, and significant effect on university patent applications. A university that evaluates patent applications for academic promotions is likely to have almost 2.3 times higher patent applications than the university that does not consider it in academic promotions; thus, we found strong support for H_1. This result shows that, in addition to increasing research results, academic promotions also create strong inducements for patenting activity and appears to provide a strong incentive mechanism patenting (see also [70]). This finding stresses the importance of reward mechanisms [47] also supports Lockett, O'Shea, and Wright's [74] notion of the need for well-established reward mechanisms to encourage and motivate university researchers to create outputs other than publications. However, the empirical evidence of Saad, Guermat, and Brodie [120] indicates that higher investment in higher education is good for patent generation, although higher subsidies have an adverse effect on patent quality.

Insert table 3 about here

There was also found to be a strong relationship between IPR awareness activities and patent applications in universities. Universities that organize IPR awareness activities, have 2.3 times higher patent applications than those, which do not, and therefore H_2 is also accepted. The relationship between IPR and innovation educational support is also significant. This finding also allows us to accept H_3. These findings show that both levels of information, education and levels of knowledge on innovation and IPR are important factors for universities that wish to increase their patent numbers. Novelty search practices were also more likely to increase patent applications of universities: the result is positive and significant at the 0.001 level, and H_4 is also accepted.

In the remaining models, we included control variables. In Model II, we have added TTO presence to the model as a control variable to see the contribution of TTO presence on university patenting. Although we had not formulated a hypothesis regarding the role of the TTO on university patent applications, the effect of TTO presence was tested and found to be positive and significant. The result proves that TTO presence positively contributes to the model and, while increasing two of the support factors' β value, they also decrease the β value of two others. In Model III, we have added university type as a control variable to see if the university type makes any difference on university patenting. Our findings show that public universities have 0.5 times fewer patent applications than those, which do not. Surprisingly, our results show no significant impact when the regional GDP level of where the university was located was included.

Discussion and conclusions

This study has analysed the impact of institutional and organizational frameworks and support factors on the propensity of patent applications by universities in Turkey as an example of an emerging economy and a developing higher education system [121]. The results of the analyses highlight a number of key findings. Firstly, that the institutional and organizational structures of the university are of major significance in influencing their patenting activity. Although both macro, national level factors and more specific individual micro level factors are important in influencing patenting (see below), this analysis has also served to highlight the role of institutional factors and organizational shaping the growth and development of IPR activity. Thus, if a university has rules and regulations that provide additional credits to researchers who pursue patent applications and also education programmes about innovation and entrepreneurship, the propensity of patent applications by that university will be much higher compared with others. It was also found that education in IPR and innovation were factors that increased the likelihood of universities to undertake patent applications, something that has not been previously identified.

Secondly, the interaction between the organization, i.e. the university, and it structures and mechanisms and individuals, in terms of academic staff, is important if complex. The relationship between organizational practices in terms of using academic promotion to incentivise patenting activity was therefore seen to be very strong influence in patenting activity. Thus, including patenting within academic performance mechanisms has been to shown to incentivize academics to engage in patenting activities, helping to increase entrepreneurial activities within Turkish universities [19], [122]. Similarly, the analysis revealed that any type of IPR awareness activities undertaken for academic staff, such as seminars and workshops, were found to stimulate university patenting activity [28], [123].

Thirdly, and related to this, the analysis found that TTOs as organizational actors within the wider university had a much less significant impact on patenting than other studies have that suggested establishing TTOs or other interface organizations within a University was important in leading to increase patenting outputs [123]. This may reflect lag effects associated with the fact that the introduction and development of TTOs within Turkey has only been very recent and that TTOs have not had time to embed themselves within the system. This recognition may be very important and pertinent to emerging economies with more weakly developed higher education and innovation systems, where establishing TTOs is often time-consuming and requires substantial investments in technical infrastructure and human resources. This also suggest long lag effects in getting TTOs up and running and where TTOs can only be truly successful within well-established innovation and entrepreneurial ecosystems.

Fourth, we found that the type of university, in terms of whether it is public or privately owned, matters for patent application. Private universities are likely to have more patent applications compared to public universities, confirming an earlier finding by Thursby, Fuller, and Thursby [124]. One of the reasons for this in Turkey could be lack of financial sources for patent application in public universities. Before Bayh-Dole Act type regulation which come into force in 2017, it was inventors who personally start patenting process and cover the cost from his/her expenses. Consequently, this limited the number of patent applications coming from public universities. A second factor could be that private universities use patent numbers as a way of promoting the brand of the university in order to new attract students.

Lastly, the research found that frameworks to encourage novelty search practices were also identified as a positive factor in university patent applications, which was an important finding and indicates that *search activities* are an essential routine and practice within universities to support patenting collaborative activity. Few studies have considered this practice within IPR

policy mechanisms [125] and should be considered more centrally within the development of a more open and connected higher education system [41].

As a result of testing Hypothesis 1, it is found that providing credit for a patent application in academic promotions increases the propensity of universities' patent application as suggested [47], [70] and [74]. When we are testing Hypothesis 2, we determined that a better understanding of IPR by academics more like to increase patenting performance, and our finding is in line with [108], [109] and [110]. The third hypothesis result showed that IPR and innovation courses in universities curricula increase patenting performance, directly supporting Govindaraju, Ghapar, and Pandiyan [108]. Finally, testing Hypothesis 4 demonstrated that universities with novelty search mechanisms have more patent applications before the project. Our finding is in line with Amabile, Conti, Coon, Lazenby, and Herron [113], Baglieri and Cesaroni [114], and Meyer [115].

Moving more specifically to a policy realm, the research results suggest a policy 'resource light' approach towards creating more entrepreneurial facing universities that a wider holistic approach towards institutional and organizational change within the University. This includes establishing TTOs and similar other interface organisations but acknowledges that other micro level behavioural and organizational support incentives focused on the individual academic are important as well. This can be seen therefore as a sequencing and prioritisation issue for economies with developing national innovation and higher education systems. Thus, the implementation of the measures identified in this study aimed at the individual behaviours of individuals should be focused on short and medium measures, whilst the establishment of more resource intensive and complex organisational structures, such as TTOs, should be prioritised for the longer term. The results of this research have also contributed more fundamentally, by exploring in greater depth behavioural factors, which motivate academics to engage in patenting and technology transfer activities. In contrast to Rizzo and Ramaciott's [48] findings for the entrepreneurial focusing on nature of universities as organisations as a whole (as reflected in such factors as funding, licensing income and size of university), this research has emphasised the importance of the *individual behaviour of academics*. Individual behaviour is associated with their response to university institutional frameworks and related to measures to increase academics' IPR awareness and knowledge surrounding patenting and integrating patenting into individual performance review mechanisms. This is a key finding of the research and suggests that influencing and shaping individual behaviours around patenting activity are as just, if not more important, as those that seek to support and develop wider institutional structures within the university. The role of IPR education and training is for individual academics is also seen as being very critical in enhancing the IP capacity of universities here and the interaction between individual behaviour and university structure and incentive frameworks are seen as important drivers here.

Our findings complement Baldini [126], who claims TTOs are a prerequisite for increasing university patenting. Overall, our findings suggest that adaptation of institutional and organizational frameworks and support factors by universities give signals to researchers and departments, which positively impacts patenting activities. Therefore, we contribute to the literature of university patenting and TTO and provide complementary approaches to increase the number of universities patenting in emerging economies.

The research has therefore important implications results for policymakers and practitioners at the specific university and wider policy level. This research indicates the importance of individual behaviour-based factors that lead to increasing levels of university patenting. Based on this study, at least, universities should consider the micro, individual academic level factors if they wish to increase their patenting results associated with the establishment performance incentives. For most emerging economies, such as Turkey, trying to establish TTOs in each university through state-supported structures is a key requisite for the increasing

commercialization and patent number of universities. Due to the different maturity levels of universities, though, the opportunity cost of establishing a TTO might not be best for all universities at least initially. The research has identified alternative solutions, which are more 'resource light' and may be better suited for less-mature universities in the short and medium run to increase their entrepreneurial outcomes, before initiating the establishment of more 'resource heavy' organisational structures, such as TTOs.

Research limitations and future research directions

This research has a number of limitations. Firstly, the data was binary, with limited questions to regenerate factors and therefore single questions were used as independent variables. Furthermore, the dependent variable was based on binary responses. Secondly, research's limitation is that there is no publicly available university patent data for the research period. Thirdly, the study also uses only one measure of intellectual property, namely patents, to measure university activity in this field, which restricts the range of IPR activities but does provide a robust benchmark of inventions that must be novel, useful and non-trivial [115]. Thus, although the use of patents does constrain the research these were the only readily available, reliable, and robust metric to evaluate such patterns. Longer-term in Turkey, it will be worthwhile to expand data collection, conduct a longitudinal study, and use different items as dependent variables, such as the number of licensing agreements, spin-offs, and commercialisation activity aspects.

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Table 1. Descriptive results and correlation coefficients

Variables		*Mean*	*SD*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1	Patent Application	0.57	0.27	1.000						
2	Academic Promotion	0.45	0.50	0.158***	1.000					
3	IPR Awareness	0.15	0.36	0.165***	0.61**	1.000				
4	IPR and Innovation Education	0.13	0.33	0.127***	0.125***	0.216***	1.000			
5	Novelty Search	0.23	0.42	0.172***	0.190***	0.200***	0.196***	1.000		
6	TTO Presence	0.38	0.49	0.052	-0.027	0.029	0.046	-0.041	1.000	
7	University Type	0.95	0.22	-0.055	0.015	-0.006	-0.003	-0.033	-0.002	1.000
8	Regional GDP	17.78	11.440	-0.007	0.030	0.082***	0.060**	0.054	0.026	0.012

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 2. Selected sample proportion by patent status

	Patent Application		
	Yes	No	*Z*
Academic Promotion	0.68	0.43	4.11***
IPR Awareness	0.33	0.14	3.77***
IPR and Innovation Education	0.25	0.11	4.17***
Novelty Search	0.44	0.21	5.30***
TTO Presence	0.54	0.46	1.44*
Public University	0.68	0.88	0.43
Regional GDP	0.21	0.24	0.60

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 3. Logistic regression analyses result

	Model I [*Patent Application (1,0)*]		**Model II** [*Patent Application (1,0)*]		**Model III** [*Patent Application (1,0)*]		**Model IV** [*Patent Application (1,0)*]	
	β	Odd Ratio	β	Odd Ratio	β	Odd Ratio	β	Odd Ratio
Constant	-3.114		-3.278		-2.663		-2.507	
Support factors								
Academic Promotion	0.867***	2.379	0.879***	2.408	0.888***	2.431	0.890***	2.435
IPR Awareness	0.849***	2.338	0.842***	2.323	0.853***	2.346	0.877***	2.403
IPR and Innovation Education	0.453*	1.573	0.427*	1.532	0.421*	1.523	0.434*	1.543
Novelty Search	0.728***	2.071	0.749***	2.114	0.733***	2.081	0.738***	2.093
Control variable								
TTO Presence			0.377**	1.458	0.378**	1.459	0.383**	1.467
Type of University					-0.659*	0.518	-0.660*	0.517
GDP Level Region							-0.09	0.991
Pseudo R²	*0.0884*		*0.0929*		*0.0964*		*0.0978*	

Percentage	*89.50*	*89.50*	*89.40*	*89.30*
χ2	*72.97**	*76.65**	*79.55**	*80.74**
Log Likelihood	*-376.166*	*-374.328*	*-372.877*	*-372.285*

*** p < 0.01, ** p < 0.05, * p < 0.10,

Figure 1. Research model