# University-Industry Partnerships in the Development of the Academic Patents: Factors for Building Trust

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**Abstract.** Our research aims to analyze the role of trust in partnerships of academic inventors that developed patented inventions. We studied the influence of similarity in the area of research, reciprocal communication, decision process similarity, team size, contact frequency, and relationship maturity in trust building. We used a mixed method approach to data collection: questionnaire and interview. We observed that patents developed in partnership are still a minority: from the 104 analyzed patents, only 37 were developed in partnership: 18 University-Industry partnerships and 19 Academic partnerships. Partnerships are mostly national. We conclude that decision process similarity and contact frequency are significant for building trust within a partnership. Academic inventors with extensive experience in patenting and in patent commercialization stressed that University-Industry partnerships are important for a better co-development of patents with a focus on the market.

**Keywords:** Academic patents · Trust · University-Industry partnership

## 1 Introduction

The University-Industry (UI) collaboration is critical to academic and companies performance [1–4]. From the perspective of academia, there has been reported a positive effect of these collaboration types on the research performance. More specifically, it was found that academics that benefit from industrial funding performed more applied research, collaborated more with other researchers both from academia and industry, and reported a higher number of scientific publications and entrepreneurial outputs [5]. Also, those were more enthusiastic about engaging in revenue-generating opportunities than others who do not collaborate [6]. Additionally, academic researchers who already have informal interactions with industry are more prone to engage in further collaborative research, as well as to spend larger proportion of their research time working with industrial researchers [7]. The UI partnerships take different forms and outputs, among which patenting an invention is a common output in the engineering field. Considering the importance of patenting as a way of academic knowledge transfer and revenue source


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for further research, we study the effects of UI partnerships throughout the development of the academic patented inventions within the Portuguese context.

On the other hand, trust is a core concept in partnerships, since trust is the link that connects partners and makes partnerships work, namely in knowledge-sharing networks [8]. Trust helps in the exchange of information, encourages informal contacts and makes the partnership more flexible and responsive to challenges [9]. In our research, we use the recent Bstieler et al.'s [10] approach to analyze the trust in partnerships of university's patented inventions. In their model, the authors study factors such as demographic similarity, reciprocal communication, decision process similarity and relationship maturity. By adapting this model, we aim to find the most influential factors in building trust in partnerships that worked on the development of patented academic inventions and contribute to better university-industry approach policies.

## 2 Literature Review

UI collaboration and the promotion of knowledge transfer may assume different modes [3]. Gulbrandsen and Smeby [5] studied the influence of industry funding in the research performance of professors in Norwegian universities and has identified four different engagement modes: patents, commercial products, establishment of firms, and consulting contracts. In turn, Boardman [11] assessed the different ways that U.S. academic researchers engage with industry and found out six different types: consultancy, students internships, working for a company, development of patent/copyright with industrial partners, commercialization of research, development of co-authored papers with industrial researchers. Similar conclusions were obtained both by Grimpe and Fier [12] and Haeussler and Colyvas [13] that had studied respectively the practices in German and in the United Kingdom universities. In a review of the literature on university-industry relations, Perkmann et al. [3] highlight the main differences between academic engagement and commercialization, stating that those are distinct types of relations with different antecedents and outputs.

The UI relationships are exposed to a high amount of uncertainty and fluctuations in the way the relationship evolve over time [14–16]. In order to build a long-term relationship and overcome uncertainties, trust between the parties is crucial. Colquitt et al. [17] stated that the research of trust is composed by two fields. The first field follows the viewpoint of Mayer et al. [18] and focuses on the issue of vulnerability, while the second field follows the viewpoint of Rousseau et al. [19] and focuses on the question of expectation. Mayer et al. [18] defined trust as a unitary construct that shows willingness to be vulnerable based on ability, integrity and benevolence of others. The assessment of ability and integrity is performed by reason based on the success of trust and consistency between words, actions and values. The evaluation of benevolence is performed by emotion, advising past situations of affection and concern. On the other hand, Rousseau et al. [19] defined trust as a psychological state of willingness to be vulnerable based upon positive expectations of the intentions or behavior of another party in uncertain situations.

De Jong and Elfring [20] mentioned that trust is fundamental for reducing uncertainty: starting from the idea of vulnerability to another and based on their knowledge of

each other, each person creates positive expectations regarding their actions and reduces the degree of uncertainty about something unpredictable - future actions. Coote et al. [21] stated that trust exists when one partner believes in the honesty, reliability and integrity of other partners. Dirks and Ferrin [22] defined interpersonal trust as the psychological state of individuals related to confidence and positive expectations in the actions of others.

Thus, trust is a key asset in collaboration between organizations and in networking creation, particularly in knowledge-sharing networks [8]. Trust is a critical asset as it increases strategic flexibility, predictability and adaptability; reduces management and acquisition costs, as well as social complexity; and encourages informal collaborative networks and collaborative innovation [9]. Schaubroeck et al. [23] observed that the reduction of individual uncertainty, triggered by trust, reinforces the quality of social exchanges. Das and Teng [24] argued that trust supports partner integration, decreases concerns about opportunistic behavior, and reduces formal contracts. Rodríguez-Pose and von Berlepsch [25] stated that the greater the interaction between partners, the greater the likelihood of building trust. The greater the trust, the easier the information sharing, open communication and conflict management [8, 26, 27].

Bstieler et al. [10] argued the mutual trust as key factor in university-industry research collaborations and examined how trust in inter-organizational relationship develops over time. The authors analyzed the influence of trust bases – demographic similarity, reciprocal communication and decision process similarity – in the mutual trust of UI research collaborations, seeing the moderating effect of relationship maturity. Bstieler et al. [10] found that relationship maturity moderates the associations of reciprocal communication and decision process similarity with trust. Considering the relevance and depth of Bstieler et al. [10]'s approach, we used in our study a similar strategy to assess the trust in university research partnerships in development of patented invention in Portuguese public academia. So, our starting question is: what are the most relevant factors to trust building in the partnerships that developed patented invention?

In the next section we present our mixed methods approach and data collection; sample and descriptive statistics; results from ordered probit regressions and interview analysis; as well as the main conclusions.

## 3 Methodology

### 3.1 Mixed Methods Approach and Data Collection

We used a mixed method approach – questionnaire and interviews – for data collection [28, 29]. The main objective of the questionnaire was to collect quantitative data related to university partnerships and its influence in the development of the academic patented inventions. In turn, the interviews allowed to collect qualitative data regarding the type and characteristics of UI collaborations.

First, we considered the questionnaire validated by Bstieler et al. [10], namely the items related to trust, reciprocal communication and decision process similarity. We also revised the items related to demographic similarity and relationship maturity. The demographic similarity was adapted to our questionnaire as research similarity and the

relationship maturity was measured by previous collaboration with partners. Additionally, we included questions about the team size and the contact frequency, given the reference in the literature to these two variables for building trust [3, 7].

Second, we requested an interview with several academic inventors with great experience in patenting. The aim was to collect a personal perspective about the relevance of UI collaborations, mainly in the development of patented inventions. Thus, the interviews with academic inventors enriched the research approach, aided the interpretation of the data and pointed out relevant suggestions.

For data collection about patents, we used the databases of Portuguese National Institute of Industrial Property (INPI) and the European Patent Office (EPO) (overlapping patents in databases were verified and eliminated). We identified the patents currently granted and in force submitted by Portuguese public universities – 570 - and we sent by e-mail the questionnaire to all first (as leader) academic inventors of each patent. It was mentioned in the email that if inventors considered more suitable, they could resend the questionnaire to another inventor of that specific patent. From these databases, we also identified the top academic inventors, i.e. who stand out as inventor of academic patented inventions. Seeing the national list of university patents and their academic inventors, we contacted inventors who had three or more university patents granted and in force. In total, we contacted a total of 43 top academic inventors to schedule an interview.

### 3.2 Sample and Descriptive Statistics

From the 570 questionnaires sent, we had 104 valid answers, corresponding to 104 university patents. As can be seen in Table 1, only 37 university patents were developed within partnerships: 18 UI partnerships and 19 academic partnerships.

**Table 1.** Types of partnerships

| Partners | Frequency |
|---|---|
| National company | 5 |
| National company + Other National university | 10 |
| National company + European university | 1 |
| European company + Other National university | 1 |
| European company + European university | 1 |
| UI partnerships | 18 |
| Other National university | 16 |
| Other National university + European university | 2 |
| European university | 1 |
| Academic partnerships | 19 |
| Total partnerships | 37 |

Partnerships are mostly national.16 resulted from collaborations with only other national university, 10 resulted from collaborations with other universities and national

companies, and 5 resulted from collaborations with only national companies. Partnerships involving other national and European partners were few and partnerships outside Europe were non-existent.

In Table 2, we present the descriptive statistics of the factors' variables analyzed in a likert scale of 7 points. As can be seen in the table, most variables present a mean of 5 points. However, we highlight the difference between the averages in research similarity: the inventors answered that have more research similarity with academic partners than with industry partners. This may be related to complement the knowledge about the development of a patented invention. On the other hand, we highlight the tolerance of risk mean in the decision process similarity factor: 4.95. Risk-taking appears to be a critical topic in decision process and eventually makes it difficult to choose more innovative paths.

**Table 2.** Descriptive statistics

| | N | Minimum | Maximum | Mean | Std. deviation |
|---|---|---|---|---|---|
| Trust | | | | | |
| Frank in dealing with us | 37 | 3 | 7 | 5,92 | 1,187 |
| Promises reliable | 37 | 3 | 7 | 5,81 | 1,309 |
| Honest | 37 | 3 | 7 | 5,84 | 1,236 |
| Partner on our side | 37 | 2 | 7 | 5,81 | 1,330 |
| Research similarity | | | | | |
| Academic partners | 32 | 1 | 7 | 5,13 | 1,862 |
| Industry partners | 18 | 1 | 7 | 3,94 | 2,164 |
| All partners | 37 | 1 | 7 | 4,68 | 1,857 |
| Reciprocal communication | | | | | |
| Timely | 37 | 1 | 7 | 5,38 | 1,622 |
| Accurate | 37 | 1 | 7 | 5,49 | 1,465 |
| Adequate | 37 | 1 | 7 | 5,78 | 1,456 |
| Complete | 37 | 1 | 7 | 5,54 | 1,538 |
| Decision process similarity | | | | | |
| Time to decision | 37 | 2 | 7 | 5,30 | 1,412 |
| Decision-making style | 37 | 1 | 7 | 5,03 | 1,554 |
| Tolerance of risk | 37 | 1 | 7 | 4,95 | 1,615 |
| Understanding of how things should be done | 37 | 2 | 7 | 5,22 | 1,397 |

In 27 cases, the collaboration with partners was prior to the development of patented invention. Regarding the team size and contact frequency, most of the teams were small (1–4 people) and with weekly/monthly contact frequency.

Additionally, from the 43 top academic inventors contacted to schedule an interview, only 19 were available. We interviewed 4 inventors from NOVA Lisboa University, 4 inventors from University of Aveiro, 2 inventors from University of Lisbon, 4 inventors from University of Minho and 5 inventors from University of Porto. The number of patents developed in partnerships was low: among the 63 patents in force of all interviewed inventors, only 11 were developed in partnership.

The interviews took a broad approach to the academic inventors' experience in patenting, not restricting only to the experience with patents in force. The analysis of partnerships in patent development, specifically the importance of collaborations with industry, was the main topic of the interviews. All the interviews were recorded and transcribed. After, we reduced raw data into structured and quantifiable data by the cataloging of the answers, identification of units of thought and frequency of response [4, 30–33].

## 4 Results

First, we performed an exploratory factorial analysis on the variables proposed by Bstieler et al. [10] as being part of the trust, reciprocal communication and decision process similarity factors. The analysis confirmed in our sample the existence of the 3 factors proposed by the authors and with the same associated variables. Thus, the variables "promises reliable", "partner on our side", "frank in dealing with us" and "honest" constitute the factor trust. In its turn, the factor reciprocal communication is composed by the variables "communication adequate", "communication accurate", "communication complete" and "communication timely". Finally, the variables "tolerance of risk", "decision-making style", "time to decision" and "understanding of how things should be done" constitute the factor decision process similarity. As can be seen in Table 3, the exploratory factorial analysis showed the KMO value is .842 and a total variance explained is 89.284%. The Bartlett's Test of Sphericity disclosed a 583.804 chi square and a .000 significance level. Considering the satisfactory values obtained in the exploratory factorial analysis, the factors were used in the following analysis.

Second, the analysis of the data collected through the questionnaires was analyzed through ordered probit regressions in order to understand how research similarity, reciprocal communication, decision process similarity, team size, contact frequency and relationship maturity influence the probability of feeling trust in the partnerships. We tested in the partnerships as a whole, and in each type of partnerships. The ordered probit regressions disclosed that there are significant associations in the partnerships as a whole (model 1) and in the UI partnerships (model 2). As can be seen in model 1 of Table 4, the decision process similarity is positively related with the probability of feel trust in the partners (p value: 3.48; 0.001 significance level). In its turn, the results showed that low contact frequency (bi-annual) is negatively related with the probability of feeling trust (p value: −3.37; 0.001 significance level). Finally, previous collaboration with partners before patent development seems to be positively related with the likelihood of feeling trust in partners (p value: 1.98; 0.05 significance level).

**Table 3.** Results of exploratory factor analysis

| Variables | Commonality | Trust | Reciprocal communication | Decision process similarity |
|---|---|---|---|---|
| Promises reliable | .963 | **.919** | .172 | .297 |
| Partner on our side | .946 | **.915** | .243 | .223 |
| Frank in dealing with us | .968 | **.891** | .343 | .236 |
| Honest | .943 | **.835** | .202 | .452 |
| Communication adequate | .851 | .244 | **.881** | .122 |
| Communication accurate | .934 | .242 | **.876** | .328 |
| Communication complete | .920 | .366 | **.847** | .262 |
| Communication timely | .867 | .084 | **.801** | .467 |
| Tolerance of risk | .892 | .260 | .200 | **.886** |
| Decision-making style | .863 | .241 | .297 | **.847** |
| Time to decision | .894 | .410 | .404 | **.750** |
| Understanding of how things should be done | .674 | .335 | .258 | **.704** |
| Variance explained (%) | | 31.990 | 29.227 | 28.067 |
| Total variance explained (%) | | 89.284 | | |
| Kaiser-Meyer-Olkin measure of sampling adequacy | | .842 | | |
| Bartlett's test of sphericity | Approx. Chi Square | 583.804 | | |
| | df | 66 | | |
| | Sig. | .000 | | |

The ordered probit regression in model of UI partnerships (model 2) showed similar results in terms of decision process similarity and contact frequency. It seems that the decision process similarity is positively related to the probability of feeling trust in UI partners (p value: 2.05; 0.05 significance level). Like model 1, the bi-annual contact frequency is negatively related with the probability of feeling trust in UI partners (p value: −2.32; 0.05 significance level), but it goes further. The model 2 reveal that a quarterly contact frequency is positively related with trust (p value: 2.14; 0.05 significance level).

**Table 4.** Results of ordered probit regressions

| | Model 1 trust in partnership | Model 2 trust in UI partnership |
|---|---|---|
| Research similarity | −0.402 | 0.622 |
| | (−1.79) | (1.16) |
| Reciprocal communication factor | 0.141 | −3.876* |
| | (0.64) | (−2.19) |
| Decision process similarity factor | 1.207*** | 1.353* |
| | (3.48) | (2.05) |
| Team size | | |
| 1–4 members | −0.255 | −8.125* |
| | (-0.42) | (−2.04) |
| 5–9 members | 0.998 | 3.724* |
| | (1.41) | (2.48) |
| 10–14 members | 0 | 0 |
| | (.) | (.) |
| Contact frequency | | |
| Bi-annual | −3.131*** | −6.733* |
| | (−3.37) | (−2.32) |
| Quarterly | 0.676 | 9.696* |
| | (0.76) | (2.14) |
| Monthly | 0.101 | 0 |
| | (0.17) | (.) |
| Weekly | 0 | 2.198 |
| | (.) | (1.45) |
| Daily | −0.868 | −0.227 |
| | (−1.02) | (−0.09) |
| Relationship maturity | | |
| No previous collaboration | 0 | 0 |
| | (.) | (.) |
| With previous collaboration | 1.354* | −0.705 |
| | (1.98) | (−0.52) |
| Pseudo $R^2$ | 0.3121 | 0.6254 |
| Number of observations | 37 | 18 |

* 0.05 significance level/** 0.01 significance level/*** 0.001significance level

Additionally, the model presented significant associations between the team size and the probability of feeling trust in UI partners. Given the results, the small teams trust less (p value: −2.04; 0.05 significance level) than bigger teams (5–9 members) (p value: 2.48; 0.05 significance level). Finally, the reciprocal communication factor is negatively related with the probability of feeling trust in UI partners (p value: −2.19; 0.05 significance level). It seems that in some cases the inventors have a good communication with partners but do not trust them, and in other cases the difficulties in communication do not undermine trust in partners. So, the ordered probit regressions disclosed that the decision process similarity seems to be related to higher trust felt in the partners, while the low contact frequency and being in small team is associated with feeling less trust in partners.

Third, we completed our study with the analysis of interviews with top academic inventors. This sample was divided into two groups: inventors who often collaborate with industry; and inventors who do not always collaborate with industry. This analysis allows the identification of common patterns in the two groups, namely it was found that those who collaborate frequently with the industry tend to consider a patent as a process of co-development. On the other hand, inventors who do not collaborate or collaborate sporadically with the industry tend to refer to a patent as something developed academically which is then sold to the industry.

Inventor 10: Companies are fundamental to research. If we want to reach the market, we must have some company interested and associated with the project. (…) It is fundamental. Do you know why? Because we don't do business at the university.

Inventor 19: From my experience, no company wants to buy patents. They want to co-develop solutions that can be patented, and they are available to recognize in monetary terms the university's ownership and to pay for it. They do not want you to contact them and say: "Look, we have a solution here that is very good. You're going to make a lot of money from it." The answer is: "No, thanks." When solutions are co-developed from a certain stage, they internalize those solutions, it becomes theirs and they are available to pay for it. They can pay more or less has negotiation is done, but they are available to pay for it.

The inventors who collaborate more with the industry highlighted the importance of trust in partners, the time needed to build trust and the bridges to connect academia to industry.

Inventor 2: One of the most important things is the process of mutual trust that must be established between academics and business people. You must trust each other. (…) It is not always easy, and it is a gradual process. You don't create it overnight. But, to start this collaboration, a high degree of trust between people is necessary. It's between people. It is not between institutions. (…) academics cannot be eternally suspicious in relation to entrepreneurs. We need to attract people who work in companies, give them understanding, do some workshops, things like that. And we should also go to companies, visit the factory, listen to people - because sometimes academics do not listen either.

Although few patents are being commercialized, we observe that those that are being commercialized are the result of partnerships with industry. The inventors stated advantages associated with collaboration with the industry, such as assertive identification of market gaps, perception of technology viability and access to facilities and networks.

Inventor 3: The things we do with the industry are obviously much more valued because the industry has an exact notion of what they want. The great advances that we made (…) the company knew what they needed. An academic does not know. In fact, it is this disconnection from the world… we aim to do things for the industry, but we never work with the industry. (…) It is very important to dialogue with those who make and produce. Because I can often get a brilliant idea, but I don't know the costs, the process complexity and reliability of what I want to do. And, therefore, this effort is lost. (…).

Inventor 11: Companies know what they want. They have this very clearly. (…) They do not radically change what they are doing. (…) If they say it is not interesting, then it is not of interest. It is so clear. It is not for technological reasons or for economic reasons…

Despite the inventors mentioned difficulties in approaching the industry and in knowledge and experience engagement, those who have frequent collaboration with industry are unanimous in recognizing the crucial role of partnerships with the industry.

## 5 Discussion and Conclusion

We analyzed the university partnerships, namely the factors that influence the development of trust, such as similarity in the area of research, reciprocal communication, decision process similarity, team size, contact frequency, and relationship maturity. We used a mix method to data collection: questionnaire and interview.

We identified the patents currently granted and in force submitted by Portuguese public universities – 570 – and sent a questionnaire to academic inventors to identify inventions developed in partnerships. Among 104 patents analyzed, we identified 37 patents developed in collaboration in partnerships: 18 UI partnerships and 19 academic partnerships. The ordered probit regressions performed in our sample showed significant associations between the factors analyzed and the trust felt in partners, as a whole, and in partners of UI partnerships. The decision process similarity and the low contact frequency showed influence in trust on both models. The results reveal that decision process similarity is positively related to trust and the bi-annual contact frequency is negatively related to trust. In addition, we interviewed the 19 top academic inventors with extensive experience in patenting at five Portuguese public universities. We analyzed 63 patents of which only 11 were developed in partnership. We highlight that the 6 academics who commercialized patents also collaborated with the industry. These academics emphasized the long-term relationship with industrial partners and the time and willingness to build trust. We observed a common pattern among these inventors: they refer to the development of the patent as a process of co-development, and not as something to be developed by academics and sold to industry. These inventors highlighted that close relationship with the industry is fundamental to assertive identification of market gaps, the perception of technological viability and access to facilities and networks.

Although our sample is not representative, the results obtained suggest that there are still few partnerships in the development of patented inventions, that is, UI partnerships. Even though in the last two decades in Portugal there has been an approximation between academia and industry, it is necessary that these organizations collaborate even more. Collaboration with the industry has benefits, namely in the development of patented invention, however, most collaborations are still strictly academic. Therefore,

public policies should continue to promote the UI partnerships through funded projects that necessarily include university and industry partners, but they need to go even further. Given the benefits of long-term relationships, it seems important to take steps to strengthen existing UI partnerships. It is necessary to bring the university and industry even closer together and to encourage the creation of long-term relationships with successful results over the years. Longitudinal research on this topic is necessary to better understand the Portuguese case and to be able to take more appropriate policies.

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