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Intellectual property and public research in biotechnology: the scientists opinion

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Brazil is considered to have an immature national innovation system. One significant situation that contributes to it is that Brazil concentrates its research efforts and inventiveness in academic environments, while the private sector has very little access to this activity. Measures are being taken to correct this situation. Nevertheless, scientists' attitudes towards the new situation will be instrumental for the success of such measures. For this reason, we have studied the behavior of Brazilian scientists from the biotechnological fields concerning Intellectual Property Rights. In this research 1032 researchers were electronically contacted and 150 responded. The 41 questions include indicators about the interviewees' perceptions about their institutions' support for patenting research results, their attitudes towards recent changes in Intellectual Property Rights legislation and about the interaction of researchers with demands from external interests.

Introduction

Brazil represents today an equation of difficult solution in public policy: it is a country with an immature innovation system (PATEL & PAVITT, 1994a;b; NELSON & WINTER, 1993), good biotechnological capability, weak industrialization and low innovativeness.

With agricultural vocation, high biodiversity and good biotechnological capability, the country is at a crossroads: either it makes use of the technological opportunity window and builds a technology management and transfer system, or it falls into another development pitfall. In case the country overcomes the historical obstacles for

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the construction of a solid innovative route, technological niches may be explored. In case it doesn't, inventive activity itself may be amputated, considering the great technological and industrial abyss that separates it from the industrialized countries.

Brazilian scientific and technological research are concentrated in universities and public research institutes (SCHWARTZMAN, 2001). Considering domestic industry's weak achievements, it is no surprise that biotechnology inventive activity follows the same pattern. If any innovative route is to be constructed in the near future, it is from these institutions.

Present research indicates that these institutions are unprepared to carry out such transfer and management functions. In a workshop conducted by the ISNAR (International Service for National Agricultural Research) in September 1999 with leaders from Mexico, Costa Rica, Colombia, Brazil and Chile, these problems were analyzed. According to the participants, the problems correspond to a list of needs that should be fulfilled, among which: access to detailed information about proprietary technology; legal support for contract management and use of proprietary technology; technical support for the economic evaluation of biotechnological products; training of researchers about basic aspects of intellectual property (FALCONI & SALAZAR, 1999).

A study conducted by the Policy Research in Engineering, Science and Technology unit at the University of Manchester among a selected group of European universities showed interesting results concerning technology transfer from universities and related organisms to industry. The selected universities came from seven countries: Sweden, Ireland, United Kingdom, Belgium, Finland, France and the Netherlands. The study found that "the growth and development of university-industry relations in Europe has lagged well behind that of North America. It was only in the mid 1980s that European universities effectively became concerned about developing commercialization and industrial ties. Before this period, academics in many European countries were legally bound not to undertake research work for industry. There were also strong cultural and social attitudes against universities collaborating with industry." Technology Transfer mechanisms were unavailable and only began to be established in the late 1980's and early 1990's (HOWELLS & MCKINLAY, 1999).

In another study carried out by the Expert Panel on the Commercialization of University Research of the Advisory Council on Science and Technology of Canada (1999), researchers found that Canadian university researchers were frustrated with the level of support available to them by university commercialization offices. The study acknowledges that much of Canadian innovation is developed in universities and related organisms and puts forward a set of recommendations to ameliorate the condition.

These recommendations include the development of a coherent Intellectual Property policy framework by the Canadian government, that Technology Transfer offices are properly resourced, increases in funding for innovation and incentives to entrepreneurial activity among university researchers.

In Brazil, many universities now are equipped with Technology Management Offices, usually within other academic extension organisms. They can be contacted through the Internet and offer basic information on patents, trademarks and copyright. Nevertheless, they lack the expertise and the means to carry out Technology Management proper.

Some studies, however, show that the change in attitude among researchers-professors in universities is the decisive factor determining the success of a robust technology transfer system to the private sector. In the United States, the *Bayh-Dole Patent and Trademark Amendments Act* was approved in 1980 and amended in 1984 by the public law 98-620. Until then, there was little interest among researchers in developing "useful" research, given the compulsory licensing of publicly financed research. The Bayh-Dole Act eliminated this. Researchers then were interested in developing technologies for the private sector and universities had to tool themselves with special organisms to handle this connection – the Technology Transfer (or Management) Offices (OFFICE OF TECHNOLOGY POLICY, 2000). Technology management offices increased in this period and the "technology transfer" professional now has a defined position and function in American institutions. There is a journal devoted only to this subject, the *Journal of Technology Transfer* (BOZEMAN, 2000). Professional associations appeared, such as the Association for University Technology Managers. The AUTM was created in 1994 and today it has more than 2700 members and grows in a rate of 10% per year.

Also in 1980, the United States Supreme Court admitted that man-made living organisms were patentable. The term "biotechnology" was formalized there. Decisions such as this opened great controversy that lasts to this day about the legitimacy of private appropriation of research results of publicly funded research, carried out by publicly paid researchers in public research institutions. According to some authors, at least 60% of university inventions, ultimately patented, were federally funded (FUJISUE, 1998; LICHT & NERLINGER ,1998).

The 1980 Supreme Court decision triggered the formation of a wave of new biotechnology firms, such as Genentech, Biogen, New England BioLabs, Cetus and Genex. Besides that, inventive activity in public research institutions became more concentrated in biotechnology. Universities created patent offices and rules to protect their "employees" intellectual property rights. The financial gains from these inventions

have grown substantially during the 90s (MOWERY et al., 2001). Today, at least 70% of the licenses that generate resources in American universities come from the life sciences (MASSING, 1997).

Nevertheless, in spite of such evidence, a small number of survey studies were carried out to monitor attitudes and behaviors of researchers and professors at universities and research institutes. Besides those conducted by Lee and Blumenthal, little is known (LEE, 1996; BLUMENTHAL et al., 1997; CAMPBELL et al., 2000; LEE, 2000).

Our study is a first step towards a better understanding of the Brazilian researcher concerning Intellectual Property Rights. It is an opinion survey with the country's biotechnology leaders. We believe that if the researcher's attitude is so instrumental for the success of technology transfer measures, it is time to understand their behavior. This knowledge may be an important tool to design adequate technology management and transfer policies to the private sector.

Materials and methods

The material used was a data base supplied by the National Council for Scientific Development (the CNPq). It contained names and certain socio-academic variables for the 1125 individuals identified as research group leaders in the sector biotechnology, from the main *biological areas* plus Biomedical Engineering and Food Technology. Besides name, address, e-mail, telephone, institution and other means of locating the individual, the data base contained: number and types of intellectual production, advised thesis, date of Ph.D., Ph.D. institution and country of origin and present institution.

The system was hosted in the undergraduation server at USP's Physics Institute, Instituto de Física da Universidade de São Paulo – IFUSP, called Socrates Server. The Socrates Server is a powerful Linux machine designed to be the computational environment of physics undergraduate students. We obtained an user at Socrates called ppi that automatically sent, received and processed the e-mails to/from the survey's subjects through a password protected WWW interface for the survey's on-line answering option.

The survey was done in three stages: the first was web answer, with two other alternatives (attachment and answer in the body of the message). Since the number of mail errors was too large, we called those researchers who had updated telephone numbers in the data base. The second trial was done to this batch. The third was a last trial to those who never answered.

Some e-mails were never corrected since the population is somewhat nomad or because the telephone number was wrong. The true universe was actually, then, much smaller.

The survey was preceded by a pre-test with a non-contaminated population. That included Ph.D.s and graduate students chosen by the method of systematic selection in the National Council for Research Development data base. We chose 148 individuals. Most of them, however, had returned e-mails since they had already moved to another institution. 45 e-mails were valid and 23 individuals answered the test. The answers had very small deviance from the survey results.

Results

Does the population represent the universe?

Of the 1032 counted members of the universe, 150 answered the questionnaire, which is 14.5% of the total. Usually, electronic researches with elite groups work with a 20% "return rate"

After we observed this fact, we proceeded to compare the population of respondents with the non-respondents according to certain indicators, and, thus, correct deviances in the respondent population. Their profile is, however, very similar.

The following indicators were used in the analysis: the average publication rate in international and national periodicals, the academic age (year of last degree), the regional origin of his/her research group, the location of his/her post-doctoral studies, if he/she has or doesn't have post-doctoral studies or holds a position higher than that offered to recently hired Ph.D's. Since later the analysis of type of institution is important to our argument, this too was studied in this comparison. Figures 1 and 2 show the results relative to the region and type of institution analysis.

The differences between the two groups were very small. Concerning international publications, the general publication rate was 10.30 (with standard deviation of 10.74). It was of 9.71 (with standard deviation of 8.72) for respondents and 10.40 (with standard deviation of 11.04) for non-respondents. The two groups are very similar, with the respondent group being more homogeneous.

This might be due to the fact that the respondent group is academically younger: they graduated from their last degree in 1989 (standard deviation 7.28) while the non-respondents did it in 1987 (standard deviation 8.75).

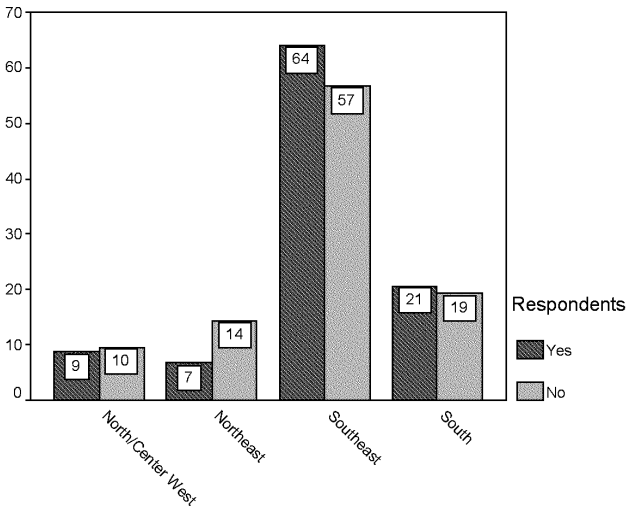

Figure 1. Analysis of the research group's origin for respondent and non-respondent researchers

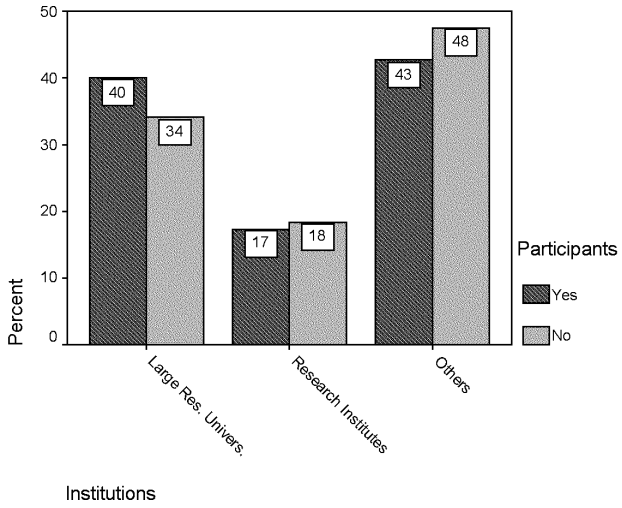

Figure 2. Analysis of type of institution for respondents and non-respondents

Among respondents 66.7% of the researchers are from Southeastern research groups, where there is the greatest concentration of research institutions. Respondents from other regions represent 33.3%. Among the non-respondents, the relationship is of 60% from the Southeastern region and 40% from other regions.

The respondent group tends to have climbed higher in the career than the non-respondent group, with higher degrees and higher positions in the university system: 56.7% of the respondents have been through post-docs and 14.3% are higher in the career than a recently hired professor. The same rates fall to 49.5% and 11% among the non-respondents, which is insignificant.

Based on these tests, we concluded that we could handle this population and draw useful conclusions from it.

Frequency analysis

The first block of questions is concerned with institutional support for patenting. Here the population is divided and we shall see that this is explained by the type of institution the individuals are affiliated to. Nevertheless, the more precise the question is, the more negative is the answer: about half of the population (55.3) is ready to agree that the institution gives general orientation for patenting. However, only 39.3% agree that it offers legal support and only 24% agrees that it offers financial support.

Except for the first block of questions, most of them were not explained by any of the socio-academic variables, showing a very homogeneous population.

Another sign of relative abandonment of this population is the lack of information that was possible to measure through this survey: when asked if the institution had a patent office 43.3% answered "no" and 24.7 answered that they had no information. Since we have the information about where the respondents' institutions were, we know they have patent offices. It is clear that the patent offices are not efficiently identifying themselves to the researcher. Another block of questions that measured the researchers' knowledge of patent systems was the one that asked if they knew if a patent which was valid in the USA was valid in the whole world: 22% of them thought it was, 54.7% thought it wasn't and 22.7% didn't know. The opposite question, which asked if a patent needed to be recognized in Brazil before being patented abroad, was answered as wrong by 64.7% of the population, but 30% had no information about it.

If on the one hand the population shows a high degree of lack of information as to the international patenting system, one the aother hand they show that they are aware of a number of issues that relate patents to their own scientific activity. For example: they know that publishing and patenting are not excluding, 69.3% of them being aware of

that. They also know that patenting may be expensive, 61.3% answering "yes" to this question. They know that patenting is just one step in the commercialization of an invention, and not the commercialization itself, 86% of them being aware of that. 76.7% of them know that the commercial gains of the invention do not belong to who has financed the research. It is hard to infer from that how far their knowledge goes as to the intricacies of commercial agreements.

The block of questions concerning what influences their choice of research theme and object has to be dealt with elsewhere because it is explained by another set of variables.

One of the most interesting findings of this study is the changing view of researchers: a few years ago, the scientific leadership was adamant in affirming their denial of any patenting benefit of biological material, especially related to biodiversity.

Today, 48% of our population totally agrees that it is right to patent biological materials and 24% partially agrees. When asked if patenting may be an important source of research funding, the figures are repetitive: 48% totally agrees and 36.7% partially agrees. When asked whom the natural resources belong: to the country where they lie or to humanity, 38% totally agree it is to the country and 26.7% partially agree with the same statement. When asked about patenting research carried out with public funds, 59.3% totally agree it is right and 28% partially agree. They also believe that increasing patenting activity reflects academically, such as increasing department's prestige: 42.7% believe it increases very much and 40% believe it increases a little. 63.3% of the population believe "very much" the interaction with the private sector increases the opportunities for graduate students.

It is important to point out that this study revealed a different attitude as to the relationship between innovative and academic research. As mentioned before, this population sees the interaction with the private sector as a source of prestige to the department. Not only that, but 56.7% believe it may open new and promising research avenues and 30.7% agree "a little" with the same statement. Also 56.7% believe "very much" that such interaction with the private sector may improve research infra-structure, with 28% agreeing "a little" with the same statement.

Most of the population (74%) did not receive any support from private corporations. However, those who did considered the different types of support they received mostly as "essential" (equipment, grants, student support, travel grants).

Influence of institutional environment

One of the central issues in the investigation concerning the possible conditioning factors over respondents' opinions is their institutional environment. In our population, we found researchers from different types of institutions.

First, we have a set of researchers employed in Large Research Institutes. In Brazil, these are all public institutions – federal or State level. Their profile tends to combine strongly academic research activity and graduate learning. During the 90's, however, important policy changes in Brazilian Science and Technology (S&T) turned these institutes to more mission oriented research. Strong budgetary restrictions related to the control of inflation have pushed them towards seeking other forms of research funding. In many cases, this has fostered a greater interaction of their teams with the private sector and also brought along a more aggressive intellectual property rights policy.

A second group of researchers is employed by large Public Research Universities. In Brazil, the public university is the chief knowledge production locus. Since the 70s, with the implantation of the national graduate research system, research activity became institutionalized and important in these universities. Research groups associated to these programs were excellence centers in Brazilian S&T system. The strengthening of this sector in the universities was a result of the educational reform by the end of the 60s, when large amounts of financial resources were channeled to the S&T system and deep institutional changes were made. Among them was the adoption of the American graduate school and department systems and the hiring of full time professors (SCHWARTZMAN, 2001).

The results of the reform were, however, not homogeneous: a few larger universities with some tradition were more successful in making use of the new institutional system and financial resources. There, research activity, coupled to graduate training, were fully institutionalized. We shall call them Large Research Universities. Their performance tended to attract back a large proportion of the graduate students sent to study abroad, which further contributed to strengthening the scientific ethos inside these institutions. This fed back into better chances of competing for grants in the funding agencies, increasing the demands in the evaluation systems and the search policies for new professors, creating a virtuous cycle well known in the S&T literature.

The indicator we used to identify these institutions in our population is the proportion of graduate students: institutions with more than 30%* of its students in the graduate system were considered Large Research Universities.

Finally, our population has a last group of researchers working in academically less prestigious higher education institutions. These institutions have a markedly regional approach and are geared to undergraduate learning. There, research activity is carried out in a less favorable environment, both as to infra-structure and to the values and attitudes that command professors' and staff behavior (BALBACHEVSKY, 1999). In our research they were classified as "other institutions". It is important to point out that this variable does not refer to the quality of research groups in each institution. It just offers an approximate indicator of the level and kind of institutional support researchers have in their environment.

With a more homogeneous population in each category, the institutional setting showed to have a high predictive value for some of the respondents' attitudes and opinions.

Figure 3. refers to question 1, relative to the support respondents feel they receive from their institutions for patenting their research results.

In spite of the fact that more than 50% of respondents tend to feel a diffuse support for patenting as commented in the frequency analysis, when this issue is explored in terms of financial and logistic support for patenting, the proportion fell respectively to 37% and 42% in the university environments. Among the Institutes' researchers, however, this proportion kept high, around 70%. These results suggest that the approval of the patent law in Brazil favored a positive attitude in all research environments. Only in the Research Institutes, however, this new condition led to concrete measures to support researchers (COUTINHO et al., 2003). Other crossings showed that this result is not affected by the place of origin of doctorate degrees, region or academic age of the researcher.

Aggregate results show that this population is fairly well informed about patenting: 74% of all respondents answered they were aware that patenting and publication are not excluding; 81% knew about the high costs associated with patenting and 91% knew that patenting does not guarantee commercialization of the invention.

* This figure was established after analyzing the enrolment curve in graduate school relative to the total number of enrolments. This data was processed from the Higher Education Registree of the Ministry of Education in the year 2000.

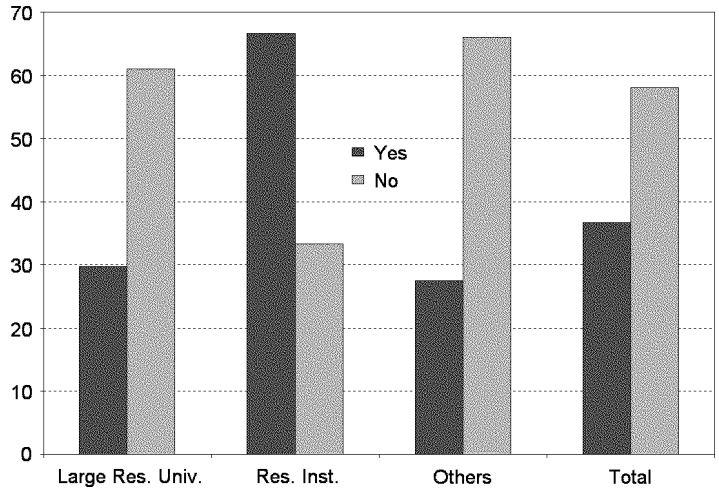

Figure 3. Institutional support for patenting by the type of institution

Also, 88.5% knew that financial gains do not revert exclusively to research funding institutions and 71% knew that patenting an invention in the United States did not have a universal value – only regional. Besides that, 93% knew that patenting abroad had no relationship with patenting in Brazil.

Even in controversial issues, the population has shown a modernizing perspective. 89% of the population agrees that patents may be an important source of funding for research in Brazil and only 27% disagree that a stricter intellectual property regulation contributes to the country's development. Only 11% agree that patenting research supported with public funds should be forbidden. Finally, 73.5% disagree that patenting biological research is wrong.

The correlation analysis of these questions show that they are relatively well structured: those who defend patenting biological research tend to sustain the idea that patents are an important source of funding for research (Pearson correlation 0.246, significant at the 0.01 level), reject the idea of prohibiting the patenting of publicly funded research (–0.206, significant at 0.05 level) and tend to reject the hypothesis that a generalized patenting process will end up creating obstacles for research development (–0.277 significant at the level 0.01).

One issue strongly polarized opinions: the question about patenting natural resources. While 51% of respondents rejected this idea, 49% tended to agree with it. Another polemic issue refers to whom belong the natural resources: while most of the population (67%) consider that they belong to the country they are found, 33% disagreed with this: natural resources would belong to humanity at general. The correlation between these two questions is very significant (0.36, significant at the 0.01 level). This result seems to reflect the community's sensibility towards bio-piracy issues.

How to choose research themes: influences external to the academy

Another issue where the institutional environment seemed to be an explanatory variable concerns the the relative permeability of researchers' agenda to problems from the "outside world". The indicators used here consisted of a group of questions that evaluated in which level problems from other actors and partners would be recognized as relevant (an influence) to the composition of the individual's research agenda. We asked in which measure research themes choice was influenced by other actors, such as NGOs, the public sector, private corporations, funding agency procurement, the region's needs, etc.

In Figure 4, we see that those researchers associated with large research universities are those who are most indifferent to external influence.

Those from Research Institutes and "other" institutions have a higher percentage of researchers influenced by the public sector. Researchers from other institutions are also permeable to influences from NGOs and regional problems.

The analysis of these answers shows different institutional settings: on one side, the large research universities, relatively insensitive to external demands. On the other side are the other institutions, where researchers seem more permeable to problems and challenges from the public sector, NGOs and the solution of regional problems. It is important to note that 77.5% of the population, regardless of their institutional setting, denied being influenced by issues from the industrial sector. This was even frequent among researchers from Research Institutes (73%). This result shows, as expected, that research institutions and industry ignore each other. This will certainly present a challenge for the implantation of any industrial innovation policy in Brazilian research institutions.

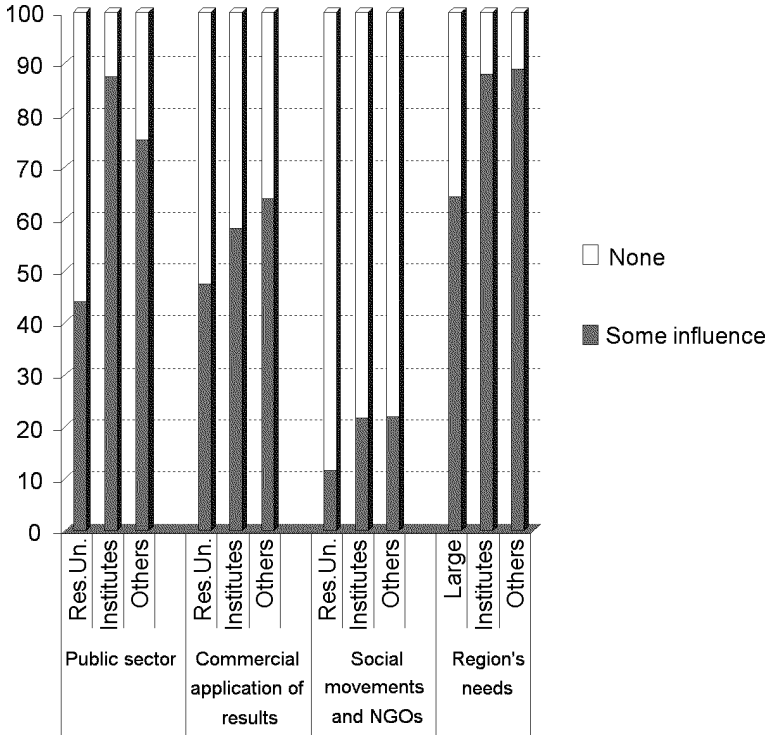

Figure 4. Influence for research choice by type of institution

Nevertheless, the interaction between research and the industrial sector is not perceived as negative by the population: 88.5% consider that this interaction may open new career opportunities for students and 89% are optimistic as to this interaction being able to open new promising research avenues. 87% consider that this interaction may contribute to improve research infra-structure. For 85% of respondents, this interaction would improve the department's prestige, while only 27% understand that this interaction may have negative results on researchers' academic prestige. There is only one dimension in which this relationship with the private sector is negatively appraised: for 49% of respondents, the interaction with the private sector would decrease the intellectual interaction among researchers and cooperative activities among research groups.

This is a favorable perspective in an academic environment where there are strongly resistant sectors to any interaction with the private sector. An analysis of the correlation between these different items showed a well structured and polarized response pattern. The respondents who tend to perceive that these interactions increase the department's prestige consider that they increase opportunities for students (Pearson correlation 0.445, significant at the 0.01 level), create new and promising avenues for research (Pearson correlation 0.386, significant at the 0.01 level) and increase the frequency of practical applications from academic research (Pearson correlation 0.441, significant at the 0.01 level). Nevertheless, those that consider that such interaction decreases professors' productivity agree that it also decreases professors academic prestige (Pearson correlation: 0.582, significant at the 0.01 level), decreases the intellectual interaction between researchers (Pearson correlation: 0.545, significant at the 0.01 level), create pressures for professors to spend too much time with commercial activities (Pearson correlation: 0.470, significant at the 0.01 level) and compromises the researcher's academic objectivity (Pearson correlation: 0.521, significant at the 0.01 level).

Concluding remarks: differentiation and polarization in the Brazilian research system

The results obtained with the data analysis pose a number of important challenges for S&T policies in the country, especially those dealing with industrial innovation. The results show a research community sensitive to the perspectives of a greater interaction with the private sector, but which in fact sees little opportunities for this to happen. The same community is aware of the open possibilities with the new patent law in Brazil, but which, except for those researchers employed in Research Institutes, finds little support in their institution for patenting and licensing their inventions.

The different environments where researchers work have a deep impact on their attitudes and behavior, especially concerning their permeability to outside influences for setting a research agenda. The large research university sector is relatively immune to these influences. This result points to a crucial issue for an innovation policy in Brazil: how to "open" these institutions, making their technological research more relevant to society and accessible to the private sector? This is yet more crucial when we consider that preliminary surveys show that this sector is responsible to graduating 57% of Ph.D.s in the country (BALBACHEVSKY & QUINTEIRO, 2002) and attracts about 70% of research funding.

These issues will remain open until the country adopts an aggressive policy for the implantation of Technology Transfer organisms in Research Universities.

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