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# CONTRIBUTIONS TO FIRM INNOVATION AT UFMG:
## An analysis of the professional master in technological innovation and intellectual property

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**UNIVERSIDADE FEDERAL DE MINAS GERAIS**
**FACULDADE DE CIÊNCIAS ECONÔMICAS**
**CENTRO DE DESENVOLVIMENTO E PLANEJAMENTO REGIONAL**

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| BBF | Biotechnology and Biopharmaceutical Formulations |
| BTI | Biopharmaceutical and Technological Innovation |
| CAPES | Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (*Coordination for the Improvement of Higher Education Personnel*) |
| GDP | Gross Domestic Product |
| IEM | Innovation and Entrepreneurship Management |
| IP | Intellectual Property |
| MEC | Ministério da Educação (*Ministry of Education*) |
| NIS | National Innovation System |
| NPPG | National Plan of Post-Graduation |
| OECD | Organization for Economic Co-operation and Development |
| PCT | Preclinical Test |
| PMTIIP | Professional Master in Technological Innovation and Intellectual Property |
| R&D | Research and Development |
| STIs | Science and Technology Institutions |
| UFMG | Universidade Federal de Minas Gerais (*Federal University of Minas Gerais*) |
| USA | United States of America |
| USP | Universidade de São Paulo (*University of São Paulo*) |

**ABSTRACT**

The present work intends to evaluate the impacts of the Professional Master in Technological Innovation and Intellectual Property of the UFMG in the contribution of the university to the firm's technological innovation and by reducing the so-called *learning divide*[1]. Besides, the role of the universities in the National Innovation Systems is addressed in a historical perspective, but also in a contemporary way, by means of the discussion on the three current main approaches about the University-Firm relationship. The *Latin American* approach, proposed by Arocena and Sutz (2003, 2005), is highlighted in this monograph for making opposition to models based on developed economies, presenting directions for the universities that are better suited for countries characterized by technological backwardness, deep social and income inequalities and scarcity of "interactive learning spaces". The methodology adopted consists of a descriptive analysis of the responses collected with a survey applied to alumni students of the program and the results reverberate the findings of Arocena and Sutz (2010) about the problem of weak knowledge demand in the South and reaffirm the importance of a more activity role of universities in the social development.

*Keywords*: Professional master, innovation, learning divides, university-firm interaction, social development.

**RESUMO**

O presente trabalho pretende avaliar os impactos do Mestrado Profissional em Inovação Tecnológica e Propriedade Intelectual da UFMG e sua contribuição para a realização do processo de inovação nas empresas reduzindo a "fragmentação do processo de aprendizado". Além disso, o papel das universidades nos Sistemas Nacionais de Inovação é abordado numa perspectiva histórica, mas também de forma contemporânea, por meio da discussão sobre as três principais abordagens atuais sobre a relação Universidade-Empresa. A abordagem latino-americana, proposta por Arocena e Sutz (2003, 2005), é destacada nesta monografia por fazer oposição a modelos baseados em economias desenvolvidas, apresentando direções para as universidades mais adequadas aos países caracterizados pelo atraso tecnológico, profundas desigualdades sociais e de renda e escassez de "espaços de aprendizagem interativos". A metodologia adotada consiste em uma análise descritiva das respostas coletadas com uma pesquisa aplicada aos ex-alunos do programa e os resultados reverberam as conclusões de Arocena e Sutz (2010) sobre o problema da fraca demanda de conhecimento no Sul e reafirmam a importância de um papel mais ativo das universidades no desenvolvimento social e econômico.

*Palavras-chave*: Mestrado profissional, inovação, fragmentação do processo de aprendizado, interação universidade-empresa, desenvolvimento social.

*JEL Code*: O39

[1] Arocena and Sutz (2010) discuss the problem of weak knowledge demand in the South and the scarcity of problem-solving activities.

## 1. INTRODUCTION

Economical modern growth is strongly based on countries capacity to foster and sustain technological innovation processes. In fact, innovation has always played an important role in the realm of the economic activities, but a significant shift in its dynamics took place after the Industrial Revolution: the rare and by-chance discoveries that stood for the bulk of innovations was substituted for an intentional and systematic effort towards it (MOKYR, 2010). In the literature, some reasons why the revolutionizing of the production technics became a constant range from the establishment of secure property rights and the limitation of predatory attitudes of governments (NORTH, 1990, 2005) to the importance of open-source communities and access cost reduction as a result of secrecy weakening (MOKYR, 2010).

Nowadays, universities and research institutes, along with firms in the productive sector, are central for the promotion of technological advances, although the understanding of how this happens and what is the role of each agent in this process may vary considerably from one author to another. For instance, Monck (1990) defends a linear model of innovation, that consistis of a unidirectional flow of systematic knowledge being used as an input for the development of technological advances. In a different direction, Rosenberg (2006) defends an interactive process with intertwined flows: technological advances can be restricted by technical problems that, in turn, will serve as inputs for the scientific elaboration. Mowery (2004) and Mowery and Sampat (2009) also defend the ideia of a bidirectional flow according to studies based on interviews or surveys held with senior industrial managers.

Three important approaches about the University-Firm interaction permeate the discussion on the role and duties of the universities in the National Innovation System, being presented in this project: the *triple helix model*, defended by Etzkowitz e Leydesdorff (2000); the *innovation systems approach*, Edquist (2005); and the *Latin American approach*, defended mainly by Arocena and Sutz (2005). In the Latin American case, the persistence of *knowledge divides* is, at the same time, cause and consequence of a production structure that focus on activities that, according to Reinert (2007), are devoid of learning potential. By learning divides, Arocena and Sutz (2010) remark the weak knowledge demand in the south, which affects the social process of advanced learning for implying scarce activities that include problem-solving. Furthermore, the authors also contest the three other approaches and their inadequacy for the reality of the Latin American countries, advocating a model of university that is more socially-oriented, to the detriment of a profit-oriented university.

The Brazilian context in the background of these discussion is formed by elements such as the progressive reduction of public universities budget, affecting negatively the proper execution of their research agenda, in an attempt of the federal government to constrain its expenditure; the escalating pressure on the returns of public investments and the search for efficiency increases; the significant expansion of professional master programs in the country and the efforts towards a stronger approximation of the academia to the productive sector and the needs of society. These programs differ significantly from the academic ones because they incorporate more directly the needs of the productive sector by prioritizing research lines that address the problems of the students' firms.

In this sense, this research project intends to understand how the Professional Master in Innovation and Intellectual Property of the UFMG can contribute to firms' innovation by reducing the learning divides, as well as the impacts that it has on the community / region where it is located. The methodology used was the analysis of the responses given by alumni students to the survey elaborated by the program's coordination. Adaptions were necessary to the survey in order to incorporate some theoretical hypothesis considered in this monograph. Considering the time restrictions associated to the process of elaborating this monograph, the results in the final section are still preliminary and are demonstrated in a descriptive form. Further unfolding may include a multivariate analysis, which will help to better cover the dataset thoroughly and in a more comprehensive way.

In order to achieve these objectives, the monograph starts with a bibliographical revision (section 2) on the role of knowledge in the modern growth – as a means to demonstrate the escalating importance of the universities in the National Systems of Innovation, as well as to present the discussions on knowledge transmission and universities role. The third section discusses the approaches of University-Firms interaction, highlighting the importance of the *Latin American* approach. The fourth section presents the results of the survey applied to the alumni students of Professional Master in Technological Innovation and Intellectual Property. And, finally, the concluding remarks, that summarizes the theoretical discussions taking into account the results of the survey.

## 2. BIBLIOGRAPHICAL REVISION ON THE ROLES OF KNOWLEDGE AND SCIENCE IN MODERN GROWTH

### 2.1. Debates on Innovation Processes: linear and interactive models and the role of universities and research

Monck (1990) argued that the advance flow was unidirectional in a way that systematic knowledge would work as an input for the creation of technology that, in its turn, would be applied to solving practical problems**.** The author also points that even until the Industrial Revolution, the weight of science in dictating the path of technology and innovation was weak. According to him, one of the most remarkable innovations in modern capitalist (mature) economies is the increasing and inexorable importance of R&D and research facilities. To the author, the importance of science as an input for progress increased through time, occupying a central role in the development of new technologies.

In a different direction Rosenberg (2006, pg. 218) says that:

> Even nowadays, many productive activities are accomplished without a deep scientific knowledge of why things work as they do. […] Thus, the normal situation in the past and to some extent also that of the present has been technologic knowledge *preceding* scientific knowledge. […] The absence of scientific knowledge does not need to be, and often is not, an insuperable obstacle. Thus, it is expected that profitable technologic knowledge be probably attained before a deeper level of scientific understanding (free translation and author's italics).

So here, the direction of the flows can be seen as intertwined: at times, technological advances face technical problems to be implemented promptly. So, part of the scientific struggle will be to solve those technical products, as a second step of the innovative process. Rosenberg says that, according to Harvey Brooks: "The basic science was motivated by the necessity to generate ancillary technology to feed the development and exploitation of an initial invention, rather than vice versa" (BROOKS, 1968 p. 399 in ROSENBERG, 1982, pg. 156).

Another view, presented by Mowery and Sampat (2009), that is much closer to that of Rosenberg, also incorporates de discussion of the role of universities in National Innovation System (NIS) according to existing cross-national data, with a focus on the OECD countries. First, the authors explain the main forces driving academic and industrial research. Whereas the former is based on the aspects discussed by Mokyr, that is to say, disclosure and publication of results and methods in an environment of lower secrecy, the latter relies much more on secrecy and limitations to opening its results and means to get to them. However, the authors also assert that these differences can be overstated, with the increase of publications by the industry, as a way to strengthen their basic science capabilities.

In fact, nowadays innovation system presents a larger collaboration of agents from these two spheres, as different knowledge sources gained more space, simultaneously. In a scenario of escalating pressure on governments for increasing the efficiency of their investments, including funds for research, universities have demonstrated, in some countries, a bending towards market and deliverable results, and industries, on the opposite direction, have incorporated more of academia research culture. This implies that there has been a boost in the linkage between universities and firms, inasmuch as they have cooperated more often lately. The extent to which universities have become more entrepreneurial depend on their structure and financing system. In the US, where universities experience higher autonomy level, they are much more market-oriented than their European counterparts. The subject, however, is full of contradictions, once some of the few existing indicators cannot shed sufficient light on the conventional view of the US as a country where U-F linkage is stronger than most OECD countries. These indicators are, for instance, the share of funds granted by industry to university research, university R&D spends as a percentage of the GDP – both relatively low in the US – and the labor mobility of high-skilled workers being absorbed by industry, where the US ranks well.

The importance played by universities in innovation systems actually varies across countries and depend on a set of variables, such as the size of a technology industry, which is very research-intensive. In addition, the way universities impact industrial innovation depends also on the field of research. It seems clear that in the biomedical sector, especially biotechnology and pharmaceuticals, university research has a major impact whereas in other technological fields, this impact is occasional and most of the relevant contributions come from nonacademic research. The perception of industry managers of research fields demonstrates this idea, with engineering and applied sciences being highlighted as more important for industrial innovation and basic fields, such as Mathematics and Physics, being rated as less important.

Another striking finding of the research conducted with the managers contests the conventional understanding of how and through which channels knowledge generated by research universities flow to industry. Patents, normally judged as highly relevant for this process, was given little importance,

whereas publications, conferences and informal interaction with researchers were pointed as more important. Although this informal contact may appear as the main gain of regional clusters, such as the science parks, for instance, studies conducted on a UK science park revealed that there was no evidence of stronger links between universities and firms than the ones stablished off the park in terms of employment of academics, sponsoring trials or research, testing and analysis, student project work and graduate employment. This must be the answer why attempts to replicate the Silicon Valley in other regions and countries proved to be difficult and produced controversial results.

Mowery and Sampat (2009) also contest the importance of patenting stimulus as an accelerator of commercial innovations. The Bayh-Dole-Act in the US, that facilitated the patenting and licensing of the results produced by publicly funded research, was based on a linear model of innovation: “if basic research results can be purchased by would-be developers, commercial innovation will be accelerated” (MOWERY & SAMPAT, 2009). There are only evidences of patenting and licensing increase after the act, but no evidence that this resulted in technologies developed by universities being transferred more efficiently to industries or commercialized. This lack of evidence is aggravated by the managers opinion on the importance of patenting as a channel of knowledge flow. The authors’ conclusion is that there has been imperative attention by the policy developers on the deliverable results of the universities, especially patents, into the detriment of interinstitutional competitiveness and other important aspects on the U-F interactions. Furthermore, this discussion also lacks sufficient tools and data to support a more grounded analysis, according to the authors.

Finally, it is important to remark that the theoretical discussion on how science is effectively transformed into technological advances and the role of universities and research institutions in this process counts on many important contributions. Klevorick et al. (1995), for instance, affirms that it is by increasing the chances of technological advances (patents and new products and/or processes, increase in productivity) that science can help firm’s R&D departments in the creation of new technological opportunities. Therefore, firms rely on scientific elaborations to innovate, for instance. The application of scientific elaborations, however, is another discussion, being direct or indirect. The translation of science to real technological advances opportunities depends on many factors, such as the productive area to which the research is related and the capacity of the firms to absorb the knowledge to which universities are important repositories (NELSON, 1990).

For D’este and Patel (2007), the transmission of knowledge between firms and universities is more complex than just patent requests and licensing. Firms interacting with universities, according to them, intend to update their knowledge, getting access to students and professors targeting specific problems. On the other hand, researchers go to firms in the search of research financing or material resources, as well as for applying their researches and acquire knowledge from this interaction.

### 2,2. Knowledge transmission in the University-Firm relation

Universities are acknowledged in the literature for its importance to technical progress. According to Nelson (1990), they can influence technological changes for two main different reasons: 1) because of the training that they provide to the workers that will later enter the labor market and also

to young scientists and 2) because of the research held by them. Complementary, Nelson also points that universities are also important repository of technological and scientific knowledge. The relation between what universities do in research and what industries develop as new technologies have a dynamic relation, according to Nelson, changing through time and fields of study. For instance, computer science and biology rely strongly on the researches being held in universities as an innovation drive to technological progress in that area, whereas aircraft and aircraft engines rely more on internal R&D of the firm.

In this sense, it becomes important to understand how firms and research institutes interact in order to produce technical advances, and also how scientific knowledge contributes to this process. At a first glance, it may be intuitive to think that innovation trajectory starts at research institutes' laboratories and flows unidirectionally towards the productive sector in the form of new products and processes. As a matter of fact, what has actually been proved, by examples from other countries and also Brazil, is that the interaction between universities and firms consists of bidirectional flows of knowledge and questions.

On one hand, the researches of Lundvall (1992), Klevorick et al. (1995), Narin et al. (1997) e Cohen et al. (2002) have shown that science and technology interactions are important for National Systems of Innovation through the transmission of knowledge developed by scientific agents to the productive sector, and on the other hand, Rosenberg (1992) discusses the role of the productive sector and its technology to provide questions to the scientific elaboration. Moreover, while referring to the role played by research institutes in the technological progress in the USA, after the II World War, Rosenberg asserts that there are two possible ways to understand this role. In the first interpretation, the author affirms that all the instrumentation technologies would eventually have been created without the support of research institutes, but in a slower pace. From this standpoint, universities were mainly related to accelerating the rhythm of technical changes rather than the shape of it. A different interpretation, however, is that universities not only dictated the rate of technological change, but also its directions and ultimately its qualitative outcomes. The existence of an experimental scientific community, rather than a pure science community, in the USA post II World War not only provided new instrumentation for researches, improving its effectiveness, but also gave birth to new questions, amplifying the original discovery potential.

Brascomb et al. (1999) supports the idea of a bi-directional flow, or a dynamic interaction between universities and firms in innovation processes. Analyzing the famous cases of the Silicon Valley and the Route 128 at the surroundings of Boston and Cambridge, the author stress that despite the common understanding that universities have played a fundamental role in coming up with the technological innovations that feed the economic models of those regions, the role of universities in economic development is much more "complicated, subtle, nuanced and complex" than a "linear model of innovation" suggests. To the author, one way to think of these interactions is by imagining a system in which universities transmit a signal to the economic agents in a given area. These signals will not be effectively absorbed if the surrounding transmitters are not turned on. Mowery et al. (2004) also support the idea of a bidirectional and mutually-dynamic flow in the University-Firm interaction. D'este and Patel (2007), complement this idea by asserting that there are different channels through which the researches held in the universities affect the productive sector. These varied channels include consultancy and contract research, joint research or training. Furthermore, the authors also noticed

through their analysis that characteristics of the researcher taken individually play a stronger impact in the interactions than the department / university itself. Finally, the authors argue that the exclusive focus on technological transfers by patents and licenses is restrict to understand U-F interactions, once most of these interactions do not intend ultimately to generate tradable results.

Adapting the aforementioned examples to the Brazilian reality, the firm cases analyzed by Suzigan and Albuquerque (2008) also support the idea of a bidirectional flow. The focus of their analysis are Brazilian outstanding firms and some specific economic sectors that have demonstrated a long and lasting record of interaction with universities and research institutes, with one providing inputs to another and vice versa. These sectors and firms have reached competitive advantages and the verification of their cooperation with research institutes and universities explain the bulk of why they are successful. The cases are 1) in the health sciences, vaccine and serum production, with the support of Oswaldo Cruz and Butantan institutes; 2) agricultural sciences, cotton, cellulose forests, grains, meats, with the support of the Brazilian Agricultural Research Agency (Embrapa) and the Campinas Agronomic Institute; 3) mining, Materials and Metallurgy Engineering, ore production, steel and special metallic alloys production, with the support of Federal University of Minas Gerais (UFMG); 4) Aeronautic Engineering and aircrafts production by Embraer, supported by the Technological Institute of Aeronautics (ITA) and the Department of Aerospace Science and Technology (DCTA); and finally 5) geosciences, oil and gas extraction by Petrobras, with the support of the Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering at the Federal University of Rio de Janeiro and also by the University of Campinas.

By assuming that these interactions between scientific and productive sectors are of relevant importance for National Systems of Innovation, and assuming that what is even more important today, according to Mokyr (1992), is "knowledge-based and innovation driven economy", it becomes relevant to understand and place Brazilian National System of Innovation in comparison to others in a way to understand why the differences between countries persist even after a significant increase in human capital expenditures in recent years. For Reinert (2007), the reason why it persists is because "they [backward countries] are specialized in activities that are devoid of learning potential". A complementary argument is that knowledge demand in backward countries is weak, as proposed by Cimoli et al. (2009) and Rodrik (2007). In fact, Reinert (ibid.) argues that in the analysis of some successful cases of economic development, not only the abundance of better educated people was enough, but also it was necessary that these people could be engaged in skill-demanding jobs. To the author, nations focusing only on knowledge supply side may be educating its population for migration.

Arocena and Sutz (2010, pp. 1-2) complement the idea of Reinert by analyzing the relation between knowledge and social processes of learning. According to the authors, the role attributed to knowledge is influenced by society's processes of advanced learning. Thereby, knowledge role is subject to 1) learning by studying, that is mainly related to the supply side of knowledge, and 2) learning by solving problems, mainly related to the demand side of knowledge. Moreover, departing from a study region (Latin America) where scientific and technological policies are being constantly reformulated, the legitimacy of resource allocation to research institute activities demands social perceptible spillovers. Therefore, the authors argue that researches that focus on local and direct reality not only have greater chances to mobilize private and public agents and their funds as well as they are more prone to social approval and support in a more sustained way.

In this sense, the Professional Master degree programs offered by higher education institutions intend to fill in a gap from knowledge supply side, allowing students to learn by studying, but also from a knowledge demand side, offering the opportunity for the development of a research agenda that connects to real problems perceived by the researchers in their working environment or, more broadly, in their activity area.

Regulated very recently by the Education Ministry (MEC) and the Coordination for the Improvement of Higher Education Personnel (CAPES), the Professional Master programs were conceived with very clear directives, stressed in their statute. In short, these programs, according to CAPES, aim at contributing to adding higher levels of competitiveness and productivity to private and public firms and organizations. Consequently, the creation of new courses in the format of a professional master must present a curricular structure that comprises up-to-date information, dominance of the adequate methodology and an application oriented to the specific professional activity. In order to follow this prescription, the academic staff of the course must be partly formed by professionals that demonstrate expertise in that given field of study and that are acknowledged by the community for their contribution to that field. Moreover, differently from traditional master programs, the final work in a PM course must be related to questions, problems and challenges identified in the student's professional activity, and also to the principal aim of the course chosen by the student. The final work can also be presented in a broader range of forms, such as articles, an innovative product or process, etc.

With such a clear purpose, Professional Master can be an important instrument in stimulating and strengthening bonds between firms and universities, with both agents providing questions and inputs for the work of one another. This potential, however, has not been formally assessed and further investigations are important to validate its social importance. From the aforesaid, the question that remains is how UFMG Professional Master - a ten years long program - has been aligned with its original objectives to reduce what Arocena and Sutz (2010) call a learning divide by contributing to the creation of more applicable knowledge.

## 3. BIBLIOGRAPHICAL REVIEW ON THE ROLE OF UNIVERSITIES: CONTRASTING THE BRAZILIAN CASE WITH DEVELOPED COUNTRIES' CASES

The article written by Paranhos et al. (2018) presents three approaches about the interactions between universities and firms, with a special focus on the idiosyncrasies of the Brazilian case, opposed to that of developed countries. The first approach consists of the *Triple Helix* model, proposed by Etzkowitz e Leydesdorff (2000), which understands the universities as the agents responsible for the commercialization of the knowledge as well as actors of development. In the second approach, called *Innovation Systems*, universities are expected to form human resources and to collaborate with firms looking forward to generate innovation. Finally, the *Latin-American* approach, advocated mainly by Sutz and Arocena (2003, 2005) understands the universities as responsible for the social development, along with the special needs of peripheral countries.

These three approaches are discussed below in more details. The aim of this chapter, therefore, is to compare them shedding light on the failures associated to the import of models for their use in conditions that fall short of those verified in the wealthy nations from where they derived.

### 3.1. The entrepreneurial university

The model proposed by Etzkowitz and Leydesdorff (2000) suggests that governments, universities and firms play each a helix in a triple helix model. These three different helixes interact with each other in three different dimensions. The first dimension comprehends the sphere of the helix itself, such as strategical alliances between firms, discussions about new missions for the universities (knowledge commercialization). The second dimension is already the interaction between two distinct helixes and, therefore, the institutional actors with the purpose of reaching innovation, such as the laws of technological transfers for firms. Finally, in the third dimension the three helixes interact for the generation of hybrid trilateral institutions, aiming to come up with proposals of high technology development, business incubators, corporate universities, government institutions of venture capital, etc.

For the proper working of the model proposed, the circulation of personnel inside the helix (vertical circulation) and inter-helix (horizontal circulation). Therefore, it is of high relevance for the model that the academic staff of a university is familiarized with the industry and its practices, inasmuch as it facilitates knowledge circulation and incites the creation of the new.

From this perspective, universities become the central actors for the generation of innovation in a society based on knowledge. They not only produce knowledge as well as transfer this knowledge for firms in the productive sector, having the profile of researches along time changed from long-term and low focus on practical results to researches mainly concerned with real and immediate questions of the productive sector. University research groups in countries where this model is verified (developed countries) become quasi-firms; entrepreneurial universities that obey five norms, according to Etzkowitz (2009): 1) knowledge capitalization, 2) interdependence with regard to the other spheres, 3) institutional independence, 4) organizational hybridization to conciliate interdependence and independence, and 5) reflexivity due to the continuous renewal of its internal structure.

Hence, entrepreneurship occupies the third mission attributed to the universities, along with teaching and researching. This framework enables the creation of spin-offs managed by students and professors according to new knowledge created from market needs and internal capabilities of the university. According to Etzkowitz (2002, 2009), “the entrepreneurial university becomes a natural incubator of an environment favorable to the creation of new interdisciplinary scientific areas and of new industrial sectors” (free translation).

The author also points that the entrepreneurial university is thereby distinct in some chief aspects that are directly linked to the abilities required for the commercialization of the knowledge that they produce. Indeed, it is required to have an academic leadership that works towards the effective planning and implementing of a strategic view, a juridical control over its intellectual property resulting from researches, an organizational capacity to transfer technology through patenting and licensing and an entrepreneurial spirit present in its teaching staff, students and managers. Besides providing the markets with human resources and knowledge, these universities become references in technological subjects, placed at the very heart of the technological frontier. Once the products of these universities are designed to further commercialization, technology transfer offices become very important.

Critics on this approach focus on the problem of the secrecy demanded by firms over discoveries under their financing. The structure of this system is strongly based on the private profits of a given firm that, otherwise, would probably not be engaged in such endeavor. This implies necessarily in knowledge exclusivity, which is particularly problematic for public universities to do, given that they are expected to share their findings with society. Furthermore, the polarization in the recent years around the financing model of public universities in Brazil add even more pressure on their visible and tradeable returns, to the detriment of the results whose evaluation is more complex and require more accurate tools to be assessed.

### 3.2. Innovation systems

This approach, as shortly mentioned before, understands the universities as a provider of human resources for the firms, as well as a strategic partner for the process of innovation. As stressed by Edquist (2005), this innovation can represent new or improved products, physical or intangible goods, new methods (technological or organizational) to fabricate, etc. Lundvall et al. (2002), in their turn, add that it means a new combination of already existing elements or a radical change, with the advent of a new combination.

Paranhos et al (2018) stress that throughout time, the heart of the innovation process was dislocated from the firm, which played the main role, to the universities, from the 20$^{th}$ century onwards. In this sense, Lundvall (2007) says that one of the most important contributions of the universities for the innovation process is the preparation of students able to solve problems in a knowledge-based economy. Freeman (1994) supports this view when affirming that the main contribution of universities' basic research for the industrial sector is indirect, by providing to the students a preparation with new and valuable knowledges and skills. The direct contributions by publication of articles, according to the authors, is secondary and have a much smaller impact on the productive sector. The article of Mowery and Sampat (2009) presented in the first chapter somehow confirms this assumption.

Another interesting linkage between universities and firms is stablished by Rosenberg (1990), for whom the firms also develop basic research in order to pave the way for applied researches in a further step. By doing so, the border separating the researchers conducted in either sphere (firms and universities) gets thinner, what allows for a more effective interaction between them. In this sense, the labor division between academic and industrial research might not be that clear, what helps the firms to better profit from the findings and information originated at the academy. Besides generating new knowledge for themselves, firms do research to incorporate the skills that will maximize the exchange with universities.

In a complementary direction, Pavitt (1984) also avers that in economic sectors strongly involved with science the dependence on universities goes beyond the demand for prepared workers and includes the help for creating new knowledge itself. The closer these two spheres are (in specific fields), the more the universities know what the social demands for that area are. Indeed, not every industry interacts continuously with the academia for researching (FREEMAN, 1994; LUNDVALL, 2002).

### 3.3. Redefining university's 3rd mission – the Latin American approach

Arocena and Sutz (2003a, 2005) and Dagnino (2003) think the university from a Latin American perspective, an approach that comprehends the problems associated with high levels of inequality and technological backwardness. In these countries, according to them, spaces where the knowledge can be applied in actual solving problems situations are scarce. "Interactive learning spaces", as they call, are the locus of the innovation process, where different actors strengthen their learning capabilities by interacting with each other in order to solve a problem. As discussed previously in this work, the social process of learning in these countries are marked by a strong learning divide, which means that despite the significant increase in the rate of tertiary enrollment in recent countries, Latin American firms demanded little from universities in a historical perspective, giving therefore rare opportunities for an important part of the learning process; the learning by solving problems.

Campos (2003) remarks that backward countries have difficulties in constantly generating social-economic spillovers that affect positively the economy because of some key factors. According to him, in these countries there is a low rate of investment and incentives for the development of innovative processes; the import of technologies postpones and create barriers for the internalization of the technological drivers; and the abundance of natural resources and cheap labor give them comparative advantages in activities that Reinert (2007) would characterize as "devoid of learning potential". Reinforcing this problem, Arocena, Bortagaray and Sutz (2008) also aver that on one hand, national companies hardly ever establish strategies that involve a demand for complex knowledge and, on the other hand, academic evaluation do not focus on the interaction with companies and their laboratories and equipment are inadequate for research. As a result, the U-F interaction under these conditions is restricted to sporadic and punctual consulting, according to the authors.

This discussion aims ultimately to change the role played by the university in Latin American countries towards a stronger social focus and remodeling universities' third mission. According to Dagnino and Thomas (2009), the dominance of the entrepreneurial university model is a recent phenomenon, starting in the decade of 1980. Before this period, the consensus was that universities should form partnerships with society in a University-Society oriented model, that has been substituted by a University-Firm model. Ever since, technological parks, incubators, technology and patent transfer offices gained much attention, redirecting universities' role for the economic development, leaving the social development in a secondary place. According to the authors, the focus of the research on economic profits for firms has led to a deepening of the inequality existing in developing countries, instead of reducing it.

The authors claiming a Latin American approach remark the paradoxes of the Science and Technology programs held in developing countries, that invariably suffer from discontinuity and resource scarcity. Governments hardly ever use their purchasing power properly, so to foster national capacities, and the protection to infant industries is absent. Besides, the programs also have a short duration, the opposite of what investments to innovation require for successfully obtaining results. The belief in a linear model of innovation, according to which advances in the scientific fields are automatically transferred to the productive sector as innovations, is also a common misunderstanding, leading to constrained results. In a macroeconomic sphere, the policies also set a hostile environment for long-term projects.

However, the aspect that Arocena e Sutz (2003a, 2005) and Dagnino (2003) address that is more related to this work is the mismatch between developing countries needs and its research priorities. The authors stress that most of the social and economic problems to be solved belong to developing countries, but at the same time, the research in these countries is oriented towards the problems faced by developed countries, that invariably decide the world's research agenda. Therefore, the distribution of the scientific and technologic capacities in the world resembles the distribution of wealth and poverty (AROCENA; SUTZ; 2003).

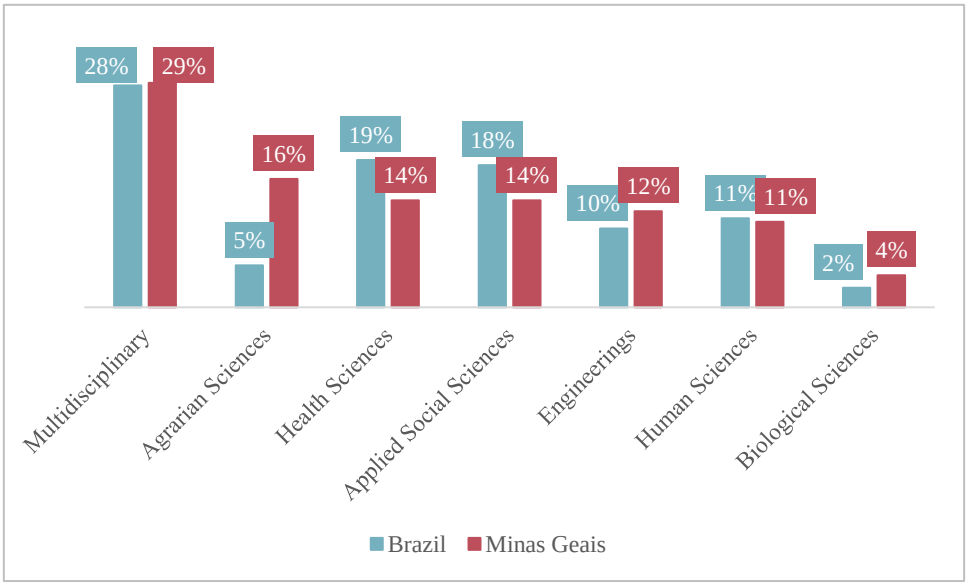
Seen in these terms, Arocena, Bortagaray and Sutz (2008) defend that the priorities of the universities should be the social issues of the places where they are located, with a rerouting of their research agenda towards the general needs of the society instead of the benefiting of a select group: the firms. The role of the university extension would therefore occupy the third mission of the university, that is the connection between the teaching and research with local needs, for which being part of the technological frontier is not a must.

## 4. NATIONAL PLAN OF POST-GRADUATION (NPPG) AND THE ACKNOWLEDGEMENT OF PROFESSIONAL MASTER PROGRAMS IN BRAZIL

The recognition of the professional master programs as a modality of post-graduate degree is a relatively recent event in Brazil. According to the National Plan of Post-Graduation (2011), until 2007 Brazil had few programs, reaching a total of 763 in 2018, according to data of CAPES (2019). The representativity of the professional programs between total *strictu sensu* post-graduate programs in Brazil is currently of 18%. In the state of Minas Gerais, the proportion is almost the same: 73 professional programs out of 444 strictu sensu post-graduate programs, which represents 16%. Minas Gerais, therefore, holds 10% of the total professional programs in the country, whereas São Paulo is responsible for 20%, Rio de Janeiro 16% and Rio Grande do Sul 10%. Together, these four states hold 56% of all professional programs in the country.

**CHART 1**

**Distribution of Professional Master Programs by Area of the Knowledge – Minas Gerais vs Brazil, 2018**




SOURCE: Capes Portal (2019). Author's own elaboration

As shown by Chart 1, in relative terms Minas Gerais concentrates more programs classified as *Multidisciplinary*, *Engineering*, *Biological Sciences* and *Agrarian Sciences* than the rest of Brazil. In particular, the area where the largest difference is verified between Minas Gerais State and Brazil is in Agrarian Sciences. Indeed, Minas Gerais holds a significant share of the Agribusiness GDP, together with São Paulo, Paraná and Mato Grosso. Therefore, a higher number of programs in the area may be the reflex of a stronger demand for applied knowledge. The 12 post-graduate programs in Agrarian Sciences in Minas Gerais represent 29% of the total programs in the area in Brazil.

The fast increase of this modality after its recognition by CAPES is aligned with the driving goals of the National Plan of 2011, which points for the importance of the post-graduation to mitigate the difficulties that it faces in approaching the productive sector by generating professionals engaged in the technological development and innovation. In the NPPG, the importance of overcoming the distances between the academia and the firms that demand innovation is remarked, and the professional programs are seen as relevant opportunities for increasing the immediate applicability of new knowledge in promoting technological innovation.

The Professional Master in Technological Innovation and Intellectual Property (PMTIIP) is also a result of this environment that provided the basis for reflecting and modernizing the post-graduation in Brazil. Born in 2008, the program was conceived to address the challenges of technological development and innovation, it was thought from the beginning to be multidisciplinary and therefore based on different departments, other than those of the professors who launched it. In fact, the three original concentration areas, Pre-clinical Test (PCT), Biotechnology and Biopharmaceutical Formulations (BBF) and Intellectual Property (IP) already counted on the participation of professionals from six schools and various departments from UFMG, such as the Biological Science Institute, the

Chemistry Department of the Exact Science Institute, the Pharmacy School, the Dentistry School, the School of Economics and the Law School.

In 2014, the program was reformulated and adjusted to better integrate a new concentration area. For this reason, two former areas, PCT and BBF, were combined to form one concentration area, named Biopharmaceutical and Technological Innovation (BTI), and a new concentration area was created, Innovation and Entrepreneurship Management (IEM). The formulation of a new area aimed at addressing an urgent and strategic topic had an immediate impact on the distribution of the students between the areas, with IEM holding the bulk of the entrants from 2014 onwards. The area is composed by the following research lines: Economics of Science and Technology; Technological and Social Innovation in the Organizations; Entrepreneurship, Labor and Competence; Legal, Economic and Social aspects of Systems of Innovation and Development. The main goal of IEM is to construct professional competences for the management of innovation and /or for the development of innovative products and technological processes along with workers in Science and Technology Institutions (STIs), public or private institutions. In the same direction, Intellectual Property shares 2 research lines with IEM, varying in a third one: Intellectual Property, Patents and Technology Transfer.

If, on one hand, the two concentration areas just mentioned seem to focus on the legal and theoretical aspects of the innovation process, its management and protection, the remaining area is more directly dedicated to innovation of products and processes itself. In fact, the research lines of Biopharmaceutical and Technological Innovation suggest a more practical approach, being its research lines: Development of New Medicines and Biopharmaceuticals; Biotechnological Approaches in the Development of Medicines; Systems of Medicines Controlled Clearance and Nanostructured Systems; Intermediary Metabolism; Preclinical Toxicity; and Neural and Humoral Control of Cardiovascular and Renal System. At a first glance, students enrolled in the concentration area BTI are more likely to come up with deliverable products that can be more easily absorbed by the market. This point will be approach later on this chapter, when analyzing the answers of students to the survey.

As a result, the program intends to impact the NIS through varied means. As appointed by Frézard (2019), it aims to elevate the innovative capacity of national firms, strengthening the niversity-firms interaction and technology transfer, the development of new medicines and innovative biotechnological products, the creation of new firms with technological basis and the development of methodologies oriented to social entrepreneurship.

### 4.1. The survey

The survey applied was an adaption of a former one, developed by the coordination of the Professional Master for alumni students. It contains three main blocks of questions, starting with the respondents' personal information, academic and professional profiles, employment status, legal nature of the institution and position occupied, weekly working hours, etc. The aim of this first block of questions is to better understand who are the graduate students, where they come from, why they chose the PMTIIP and what were the results that they produced with it.

The second block of questions explores more directly the perceived impacts of the program on the student personal trajectory, the contributions to the firms in terms of technological innovation and the evaluation by the students of factors that could affect their performances during the masters, such as class timetables, infrastructure, quality and relevance of the classes – intern factors –, as well as some external factors, as the economic and political situations, professional stability, time available for the disciplines and the dissertation, etc. The first two blocks of questions are more important for the analysis intended, whereas the third one concerns more the coordination of the Program, although some of this information may be used when it is convenient.

The adaption made over the original survey consists of the insertion of two questions. The first one regards the legal nature of the institutions / firms (private, public) where the students worked and was asked two times, referring to their employment status at the beginning of the masters and their current status. The second question is the assessment of two affirmatives deduced from the interviews conducted previously. The affirmatives are:

1. The PMTIIP creates by itself conditions to ensure that its final results be an innovative product, process or service presented by the students;
2. The generation of an innovative product, process or service as a final result of the master program depends on other factors (research supervisor chosen, personal trajectories of the students, opportunities provided during undergraduate or master degree) not only on the masters itself.

The students were given four options for each affirmative: 1) Completely disagree, 2) Partially disagree, 3) Partially agree, and 4) Completely agree. The question intends to extract from the students their evaluation on whether the Program is institutionally prepared for stimulating an environment of innovations and solutions for the productive sector, through the firms where the students work, or if coming up with a new product, service or process depends more on the personal path of each graduate and their own experiences, such as the project supervisor, previous undergraduate experiences, firm's sector or/and position at work, etc.

The total number of respondents represents 54% of the whole universe of students who presented a final thesis to the program. In absolute terms, the survey obtained 55 respondents out of 102 graduated students. It is important to warn that students who gave up on the program before graduating were not considered.

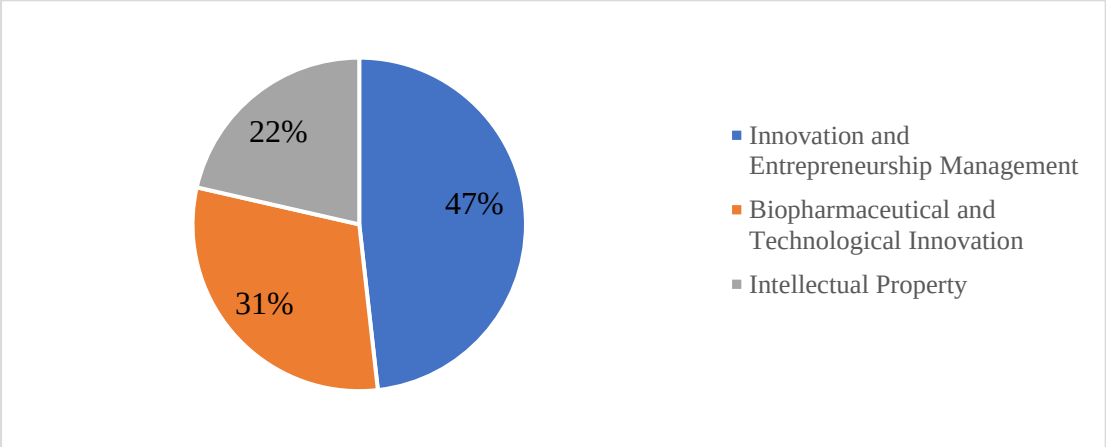
### 4.2. Preliminary data

The chart 2 presents how the students are organized in terms of their undergraduate majors. Four undergraduate courses hold 58,2% of the students. Before going through the charts, it is worth warning that in most of the questions the student could pick more than one answer, or write his own in an open area. Therefore, the total percentage may exceed 100%.

When grouped in the area of the knowledge, the four most representative areas in which students hold an undergraduate degree are *health sciences* (20%), *applied social sciences* (18%), *engineering* (18%) and *social sciences* (18%). Other areas include *biological sciences* (13%), *exact and earth sciences* (4%), *human sciences* (4%), *multidisciplinary* (4%) and *agrarian sciences* (2%). The most representative undergraduate majors of these students are *Law* (18.2%), *Pharmacy* (16.4%), *Production Engineering* (12.7%) and *Biology* (10.9%).

The PMTIIP of the UFMG contains currently 3 concentration areas in which the graduate can pursue a master degree: a) Biopharmaceutical and Technological Innovation, b) Intellectual Property and c) Innovation and Entrepreneurship Management. Before being reformulated in 2014, the program was divided into different concentration areas, namely 1) Pre-clinical Test, 2) Biotechnology and Pharmaceutical Formulations and 3) Intellectual Property. In order to avoid misunderstandings, some few students who answered that their concentration areas were the extinct 1 and 2 were relocated to the new concentration area that comprehends both of them: Biopharmaceutical and Technological Innovation.

**CHART 2**
**Students by concentration area**




SOURCE: Professional Master's Alumni Survey. Author's own elaboration

The reasons why these students decided to enroll in one of the concentration areas of the Professional Master is a good information for understanding what they were looking for at the moment they decided to choose a program whose focus was Innovation and Intellectual Property instead of academic and more traditional programs. According to the survey, 79% of the students chose the PMTIIP in a search for a better qualification, 44% think it is more adequate for them than an academic master, 38% were searching for solutions to their works and 27% were searching an approximation to the university and the researchers.

Most of the students presented their final results in the form of a dissertation (60%), but a significant part of them (36%) also published articles, chapters of books or books, innovative process or product, a new model of innovation management, etc. The remaining 4% are two students who presented only a patent request each. Table 1 shows the other products presented by the students who also submitted a dissertation.

**TABLE 1**
**Final products other than dissertation**

| Final Product | Nº Products |
|---|---|
| Book chapter or book | 6 |
| Networking and partnerships | 5 |
| Complete article published and classified in the Webqualis of the area | 3 |
| New model of innovation management | 3 |
| Patent request | 3 |
| Innovative process or product | 2 |
| Proposal of revision / inclusion of legal or regulatory aspects | 2 |
| Prototype | 2 |
| Innovative service | 2 |
| Presentation in three international conferences | 1 |
| Booklet or promotion material | 1 |
| Business plan | 1 |
| Proposal of a new enterprise | 1 |
| Technical report | 1 |
| **Total** | **33** |

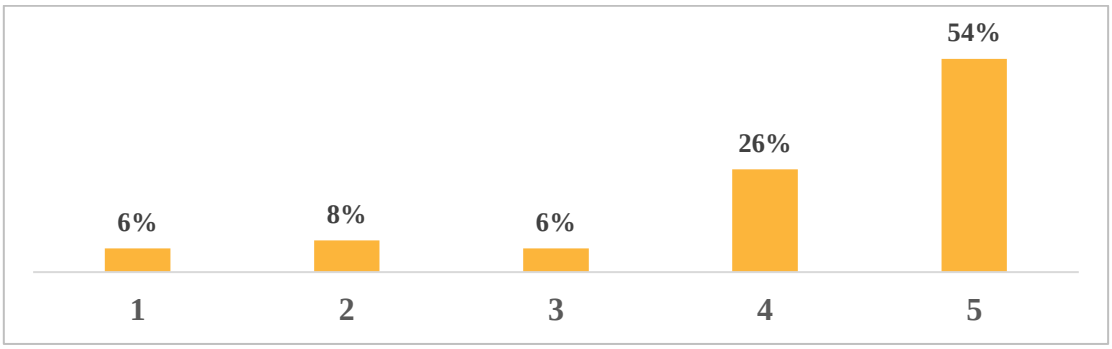
SOURCE: Professional Master's Alumni Survey. Author's own elaboration

### 4.3. Linkages between firms and the master program

This section intends to introduce the discussion about the students' employment status and its relation to the master program. As described by its driving goals, professional master programs target employed students who aim to create something departing from the daily questions, problems and situations faced at work, in a more practical approach that will eventually lead to a solution, an innovation of any type and etc. In fact, the majority of students enrolled in PMTIIP had a formal job at the beginning of their master degree. According to the survey, 84% of the students had a formal job when they started the masters, whereas only 16% did not. These percentages change significantly by the end of the program, when the number of unemployed stepped up to 36% of the students, against 64% employed.

When analyzing the legal nature of the institutions / firms where students worked, 57% were private firms and 37% public organizations. As one could imagine, the vast majority of the public servants occupied positions at UFMG, what can be explained mainly by the proximity between students' classes and work, the influence of the institution over its employees, its state and national importance, more flexibility and understanding by the employer, etc. On the other hand, the group of students hired by private institutions were more equally distributed between a higher number of firms. In addition, 90% of the employed students dedicated 31 hours or more a week for their jobs, a very distinct situation from what is observed with students in traditional master programs, especially those of federal and state universities. Therefore, intertwining the problems faced at work by the students and their research questions can theoretically be an effective way to reduce the trade-off between working and studying hours. When asked about the affinity between their professional activities and the research developed in the Program, in a scale from 1 to 5, where 1 means minimum affinity and 5 maximum affinity, the result was:

**CHART 3**
**Affinity between research project and professional activity**




SOURCE: Professional Master's Alumni Survey. Author's own elaboration

The number of respondents for this question was 50, out of the total 55, which means that 5 students chose not to answer the question probably because they did not exercise any professional activity at any time throughout the whole program.

As shown by the chart, most of the students answered that their research projects had strong affinity with the work they executed in their respective jobs: 54% said that the affinity was maximum (5), 26% said that this affinity was very high (4), and 20% answered that there was few or no affinity between the two (levels 1, 2 and 3). The result for this question was, somehow, expected, once this affinity is part of the application process and counts positively for the contenders who have it at a higher level. However, this higher level of affinity is not necessarily converted into significant impacts for the student's firm, as will be show ahead.

Another striking finding that can be cross-checked against this is the number of unemployed students, as mentioned, that increases significantly throughout the program, indicating that for many graduates conciliating both activities might have been hard or not a good strategy. The fact is that it does not seem clear that the firm's strategy matches with the strategies of its employees who decided to look for a better qualification, even when it means a potential solution for the firm's problems and challenges. Indeed, a large number of students left the program without concluding it and the main reason appointed was time overlap. The gap between the employment status of the students at the beginning of the program and the end is mitigated throughout time, after the graduation. In fact, the program creates a certain instability in the students' path, which is gradually eliminated afterwards.

When asked about their current employment status, 76% are employed and only 24% are unemployed, a reduction of 12 p.p. in comparison to the unemployment rate verified by graduating time. When analyzing the group of students who graduated in a period of at least two years ago, 79% are employed and 21% unemployed, a slight reduction in comparison to the current 24% unemployed but still the rate is higher than that observed between students in the beginning of the program.

Another interesting pattern observed is the increase of students employed in public institutions along time. If, on one hand, 57% of the employed students were initially in private firms and 37% in public ones, the former group falls to 52% and the latter increases up to 43%. Once this work analyses

a small sample, slight changes may not be statistically significant when tested. However, it is reasonable to think that there is a move towards public institutions after graduating in the PMTIIP because most of the offices and occupations regarding technological transfer, intellectual property and so forth are mainly concerned by public institutions.

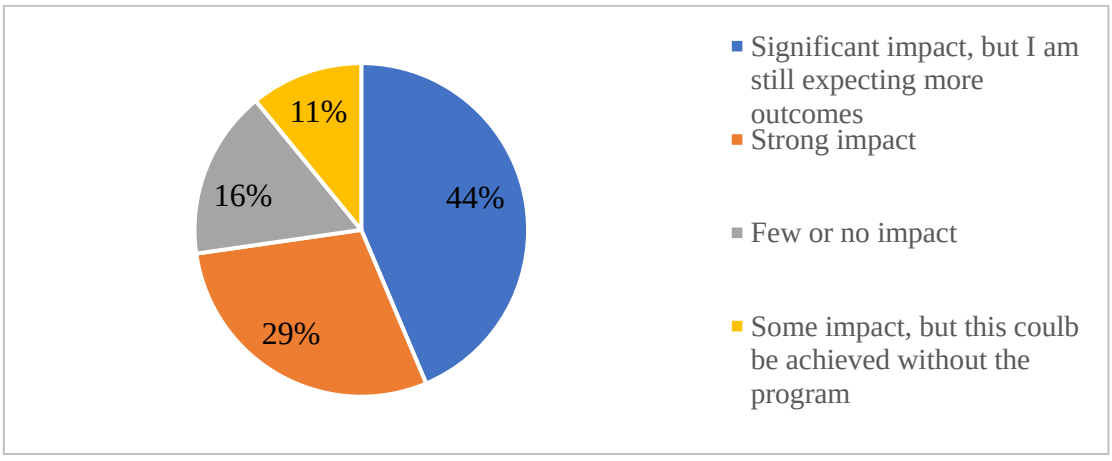
### 4.4. Assessing the impacts of the program (personal, firm, region, community)

This section addresses more directly the impacts of the PMTIIP on the trajectories of the students, as well as on their firms and the region / community they belong to. For that matter, the students answered a series of questions in the survey that can give a more comprehensive view of the master in terms of how it affects the students and their surroundings. Taking into account that a relevant group of students answered that the affinity between their research projects and their work was maximum (see chart 2), it is also interesting to analyze separately whether for this group the impacts were more significant or not.

In this sense, the chart 3 informs the distribution of students between the levels of impacts of the master in their personal trajectory. As it can be seen, for 44% of them, the impacts were significant, but there are still expectations of further outcomes. For this group, the impacts consisted mainly of job change, a higher engagement with the innovation management and technological innovation in the firm or a promotion. For 29% of the students, the impact was strong, and it also came in form of a higher engagement with the departments dedicated to innovation in their firms and also the hiring for another firm / institution. The remaining 27% consists of students who affirmed that the program had few or no impact in their trajectories, or impacts that could be achieved without the program.

**CHART 4**

**Program's impact on personal trajectory**




SOURCE: Professional Master's Alumni Survey. Author's own elaboration

The table 5 lists all the impacts informed by the students and is organized by the number of times these impacts were chosen in the survey. It is worth remembering that as each student could choose more than one answer, the total number of impacts can surpass the 55 students. As it can be seen, out of the 55 students, being more engaged in the innovation department of the firm was cited by 18 students as one impact in their personal trajectory.

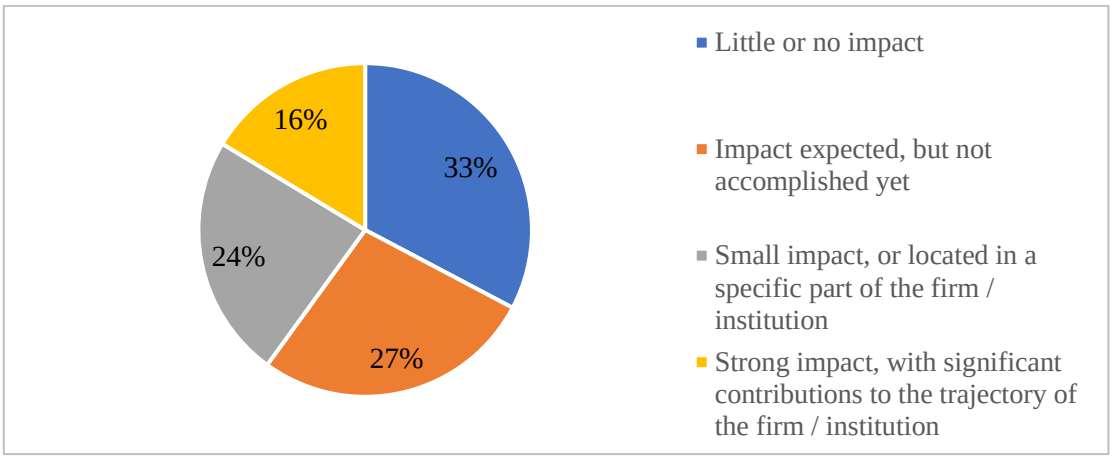
**TABLE 2**
**Forms of impact perceived with the program in personal trajectory**

| How did it impact? | Nº Students |
|---|---|
| I started being more engaged in the innovation management or in the technological innovation in the firm / institution | 18 |
| Contributed for my hiring in another firm / institution | 15 |
| Does not apply | 14 |
| Professional qualification | 7 |
| Contributed for me to start my own business | 5 |
| I was promoted by the same firm /institution | 4 |
| I changed the sector I worked in the firm / institution | 3 |
| I migrated from the productive sector to the academia | 2 |
| I started the doctorate | 2 |
| Salary increase | 1 |
| Negative impact | 1 |
| No impact | 1 |
| I moved to the academia without leaving the productive sector | 1 |

Source: Professional Master's Alumni Survey. Author's own elaboration

On the other hand, when asked about the impacts on their firms' contribution to the innovation process (employed students), 33% of the students answered that the program had little or no impact on it and 27% are still expecting some impact. Only 16% answered that it had a strong impact on the firm, in form of increase in the innovative capacity or the innovation management of the firm, the generation of a spin-off and the strengthening of the interaction between firm and university. Some other interesting impacts mentioned are the generation of a product or process to improve people's quality of life and the generation of a patented product or process with a potential for licensing. For 24% of the students, the program had a localized impact in a specific area.

**CHART 5**
**Program's impact on the contribution of the firm to the technological innovation**




SOURCE: Professional Master's Alumni Survey. Author's own elaboration

The table 6 shows the main impacts of the PMTIIP on the contributions of the firm to the innovation process by the number of times each contribution was cited.

**TABLE 3**
**Impacts perceived by the students on the innovation capacities of the firm**

| Type of contribution | Nº Students |
|---|---|
| Does not apply | 27 |
| It increased the innovative capacity or the innovation management of the firm / institution I worked for | 10 |
| The sector responsible for the innovation management or the technological innovation in the firm / organization was expanded | 9 |
| It increased the interaction between the firm / institution with the university | 7 |
| It contributed for generating a new product or process to improve the quality of life of a group of people or of society as a whole | 5 |
| In contributed for generating a patented product / process, with a licensing potential | 5 |
| It contributed for generating a spin-off | 4 |
| It contributed with alterations in regulatory aspects, legal or pre-existing policies in different spheres of the public power | 2 |
| It contributed with legal advice geared towards innovation | 1 |
| It contributed by reducing costs of the public or private sector | 1 |
| It contributed by promoting more research in the area | 1 |
| Professional qualification | 1 |

Source: Professional Master's Alumni Survey. Author's own elaboration

When asked about what they believed to be the main impacts of the PMTIIP on society, students answered:

**TABLE 4**
**Impacts on the region / community**

| Impact for the Region / Community | Nº Students |
|---|---|
| Training of Human Resources (qualification of alumni in their firm / institution | 44 |
| Product, process or service generated from the dissertation | 27 |
| Intellectual production generated by the dissertation | 23 |
| Identification of new products and markets | 1 |
| I do not know | 1 |
| The real interaction with the region / market / community provided by the program | 1 |
| The impact depends on the theme chosen, being more or less practical | 1 |
| Resources return to the public university | 1 |

Source: Professional Master's Alumni Survey. Author's own elaboration

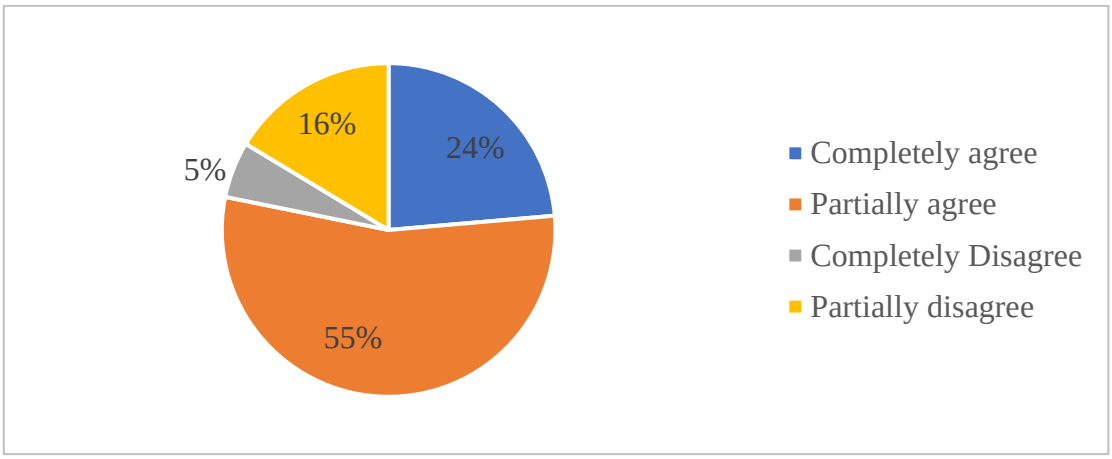
The result is aligned with the theoretical approaches that understand the universities as important providers of human resources for the National Innovation Systems. In fact, 80% of the students believe that the program impacts the community and the region where it is inserted mainly by the training of human resources. Furthermore, 50% of the students also highlighted the importance of the products, processes and services generated by the program, and 42% also emphasized the importance of the intellectual production of the dissertations.

Finally, they evaluated the affirmation mentioned in the beginning of the chapter. As a means to facilitate the viewing of the affirmation and the students' responses, it is quoted again below:

1. The PMTIIP creates by itself conditions to ensure that its final results be an innovative product, process or service presented by the students;
2. The generation of an innovative product, process or service as a final result of the master program depends on other factors (research supervisor chosen, personal trajectories of the students, opportunities provided during undergraduate or master degree) not only on the masters itself.

These affirmatives are somehow complementary, which means that a student can agree completely that the PMTIIP offers the conditions for the generation of new products and processes and also agree that other elements are also significant for the results.

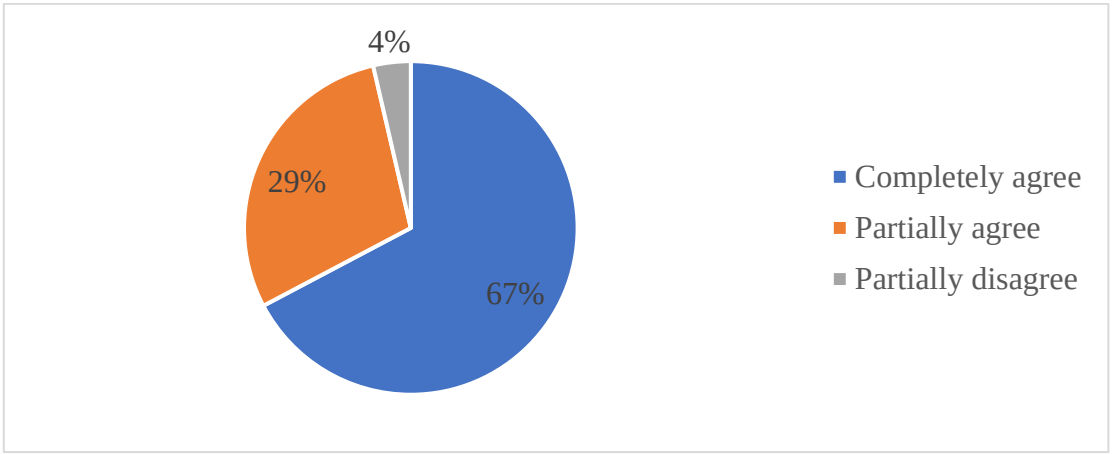
**CHART 6**
**Students' evaluation of affirmation 1**




SOURCE: Professional Master's Alumni Survey. Author's own elaboration

A total of 79% of the students completely or partially agree that the conditions for the generation of innovation in the PMTIIP are given institutionally. However, the responses to the second affirmation also show that 96% of the students completely or partially agree that the personal path of each student and the choices that they make during the program or even before may condition the final result.

**CHART 7**
**Students' evaluation of affirmation 2**




SOURCE: Professional Master's Alumni Survey. Author's own elaboration

### 4.5. The affinity 5 group

A hypothesis that can be tested is that the stronger the affinity between the researches developed by the students and the work they execute at their firms, the more direct is the impact of the program on the firms, region and community. This makes sense if one think that the closer the research, the easier it is for the final product to be incorporated by the firm or institution. Also, a higher affinity can also have a positive impact on the permanence of the student at the firm and reduce the program evasion, if the study brings excitement to the graduate and some kind of the support by a more interested firm. A possible way to test for these hypotheses is by isolating the group of students who attested affinity 5 and analyze if their evaluation of the program impact is any different.

The employment status of the group in the beginning of the course does not count much for comparisons with the rest of the group, because the bulk of who attested affinity 5 for the relation work / research had to be employed to answer so. However, it is interesting to see if throughout the course, the number of unemployed students grew less for this group than for the rest of the sample, as well as compare the current status of each group. The table 8 summarizes these numbers:

**TABLE 5**
**Comparing the employment status of the groups**

| Group | Beginning | | End | | Currently | |
|---|---|---|---|---|---|---|
| | Employed | Unemployed | Employed | Unemployed | Employed | Unemployed |
| **Affinity 5** | 93% | 7% | 74% | 26% | 78% | 22% |
| **Affinities 1 to 4** | 87% | 13% | 61% | 39% | 83% | 17% |

Source: Professional Master's Alumni Survey. Author's own elaboration

By the end of the course, the *affinity 5 group* had an employment rate 13 p.p. higher than the whole sample, but it also represented a decrease of 19 p.p. in comparison to the rate in the beginning of the course, whereas for the rest of the sample the decrease was of 26 p.p. Currently, the *affinity 5 group* has a higher unemployment rate than the whole sample.

When compared in terms of quantity and type of products that each group generated with the program, the affinity 5 group generated a total of 44 products, an average 1,6 products for each student, whereas the remaining group generated a total of 32 products, 1,4 products for each student. In the former group, 59% of the students (16) presented only a dissertation as final product, whereas for the latter, this percentage was of 65% of the students. Finally, when one compares the percentage of *deliverable products* – products that can be more directly commercialized or used by a firm / institution, such as patents, new processes, products or services – of each group, the affinity 5 group delivered 38% of its products as deliverable ones, whereas for the remaining group this percentage was of 28%: a difference of 10 p.p.

A final and very striking difference in the answers of the two groups was verified in the analysis of the impact that the PMTIIP caused on the firm's contribution to the technological innovation. In the affinity 5 group, 30% of the students affirmed that the PMTIIP had a strong impact, whereas for the rest of the sample (affinities 1 to 4), only for 4% of the students the PMTIIP had strong impacts. For 61% of these students (affinities 1 to 4), the impacts are small and localized in some specific areas, or even do not exist, whereas for the group of maximum affinity the impacts are small or inexistent for 48% of the students.

## 5. CONCLUDING REMARKS

Following the approach proposed by Arocena and Sutz (2010), this monograph presented exploratory research on the problem of learning divides in the South, analyzing the impacts of the Professional Master in Technological Innovation and Intellectual Property from UFMG to firms' technological innovation. The methodology used merges bibliographical revisions on the role of knowledge in modern growth, knowledge transmission in the U-F interaction, approaches to the role of universities in the U-F relationship and qualitative data collected with the support of a survey applied to alumni students of the program.

Although it has been demonstrated by the discussions above that science and technology policies oriented towards deliverable and measurable results (patents requests and licensing, commercializing products and services, etc.) have consistently underestimated the more comprehensive contributions of universities and basic researches to technological advances (MOWERY & SAMPAT, 2009), the survey applied to the students that compose the sample has a clear bias towards measuring exactly these results. In fact, contributions in form of dissertations, articles, books, conferences and other important scientific dissemination materials are characterized by long-term returns and therefore require more sophisticated tools to be properly assessed.

The results of the survey shed light on some interesting contributions of the Professional Master to the technological innovation of the firm, but also, to more comprehensive social impacts generated. Promptly, it is possible to verify that, when compared to academic master programs, the professional ones have some advantages as it comes to direct contributions to the productive sector. Starting with the final products other than dissertations (also presented in academic programs), a small part of what has been produced could easily be achieved in a traditional program, such as publications, books, articles, etc. However, a significant part of the product consists of new products and services, partnerships and networking, patent requests, new model of innovation management, etc. The stronger the affinity between the research developed by the student and the work executed in the firm, the bigger the impact on the trajectory of the firm, according to the students. In fact, the results of the affinity 5 group are more consistent with the idea of creating a program dedicated to solving actual problems of firms than the rest. They suffered less from the instabilities of the master (smaller increase of unemployment) and testified a stronger impact to their firm's contributions to technological innovation.

In general terms, it is also possible to reverberate the weak knowledge demand described by Arocena and Sutz (2010) in this case. In fact, almost the totality of the students searched for the program

by personal, without an institutional linkage from the part of the firm, which inevitably led to high levels of withdrawal, in the group of students who did not conclude the program, and unemployment increase in the group that concluded the master. Other reasons why the unemployment rate of the sample increased are also relevant, but departing from the students personal statements (an open question in the end of the survey), the pursuit of a better qualification by means of continuing the program led inevitably to quitting their jobs, given the difficulties of aligning firm's and personal interests.

Another interesting finding relates the legal nature of the institutions where students were employed and their work position throughout time. Most of the technological transfer and technological innovation offices belong to public institutions (such as UFMG) or private foundations, such as FIEMG. Considering the skills acquired with a post-graduation in Intellectual Property and Innovation and Entrepreneurship Management – the two largest concentration areas in number of students –, these places more easily absorbed the graduated students.

Another interesting finding of the research is that although 79% of the students affirm that the program creates, by itself, conditions for the student successfully contribute to the technological innovation, 96% are convinced that the personal path of each student and their previous experiences (academic, professional, undergraduate experiences, field of study) also determine the success of the graduates and their project intentions. An outstanding example of a student – who managed to create various companies of technological basis after graduating, becoming a researcher at the MIT and being currently a professor at the Biology department – corroborates these affirmations and adds that the presence of personnel with management skills in projects with potential of commercialization of technologies is a central element for the success of the endeavor.

Finally, this work also accomplishes the need of creating tools for evaluating the impacts of professional master programs on the technological advances and, consequently, on the National Innovation System, once they are significantly different from the conventional master programs and consist of a more recent event in the history of Brazilian post-graduation. Besides, it also advocates the expansion of the professional programs within public and private research institutions and the approximation of their research agenda to urgent questions faced by Latin American countries, to the detriment of the so popular and desired model of entrepreneurial universities. A lot can be achieved with universities current research capacities towards the reduction of social problems that are not emphasized in the international scientific realm, where developed countries' issues rule.

**REFERENCES**

AROCENA, R.; GÖRANSSON, B.; SUTZ, J. *Knowledge Policies and Universities in Developing Countries: Inclusive Development and the "Developmental University"*. Technology in Society 41: 10–20. 2015.

AROCENA, R.; BORTAGARAY, I.; SUTZ, J. *Reforma universitaria y desarollo*. Montevideo: Tradinco, 2008.

AROCENA, R.; SUTZ, J. *Subdesarrollo e innovación: Navegando contra el viento*. [S.l.]: Cambridge University Press, 2003. Madrid p.

_____. Conhecimento, inovação e aprendizado: sistemas e políticas no Norte e no Sul. In: Conhecimento, sistemas de inovação e desenvolvimento. Rio de Janeiro: Editora UFRJ/Contraponto., 2005.

_____. Weak knowledge demand in the South: learning divides and innovation policies. *Science and Public Policy*, Oxford, UK, 2010.

BRASCOMB, L. M.; KODAMA, F.; FLORIDA, R. *Industrializing knowledge – universityindustry linkages in Japan and the United States*. Cambridge-Londres: The MIT Press, 1999.

Britto, G., Santos, U. P. dos, Kruss, G., & Albuquerque, E. (2015). Redes globais de inovação e interações universidade-empresa: uma análise exploratória de dados. *Revista Brasileira De Inovação, 14*(1), 163-192. Available in: <https://doi.org/10.20396/rbi.v14i1.8649093>. Last accessed on 29th June, 2019.

CAPES. *Plano Nacional de Pós-Graduação (PNPG) 2011-2020.* Available at: <https://www.capes.gov.br/images/stories/download/PNPG_Miolo_V2.pdf>. Last accessed on 15th Novembre, 2019.

_____. *Mestrado profissional: o que é?*. Available in: <https://capes.gov.br/pt/avaliacao/sobre-a-avaliacao/mestrado-profissional-o-que-e>. Last accessed on 29th June, 2019.

_____. *Programas da Pós-Graduação Stricto Sensu no Brasil (2017 a 2020)*. Dados abetos da CAPES. 2019. Available at: <https://dadosabertos.capes.gov.br/dataset/2017-a-2020-programas-da-pos-graduacao-stricto-sensu-no-brasil>. Last accessed on 10th Novembre, 2019.

CASSIOLATO, J. LASTRES, H. Discussing Innovation and Development: *Converging Points between the Latin American School and the Innovation Systems Perspective*. 2008. Globelics Working Paper Series.

CIMOLI, M.; FERRAZ, C. J.; PRIMI, A. *Science, technology and innovation policies in global open economies: reflections from Latin America and the Caribbean*, GCG Georgetown University, 3(1), 32–59, 2009. Available at <http://gcg.universia.net/pdfs_ revistas/articulo_118_1238082739847.pdf>, last accessed on 5th June 2019.

COHEN, W. et al. Links and impacts: the influence of public R&D on industrial research. *Management Science*, v. 48, n. 1, p. 1-23, 2002.

COUTINHO, L. G. *Regimes Macroeconômicos e Estratégias de Negócios: Uma Política Industrial Alternativa Para o Brasil No Século XXI*. In Conhecimento, Sistemas de Inovação e Desenvolvimento, edited by Helena Lastres, Jose Cassiolato, and Ana Arroio, 429–48. 2005. Rio de Janeiro: UFRJ.

CUNHA, L. A. *A universidade temporã*. Rio de Janeiro: Francisco Alves, 1980.

DAGNINO, R. A Relação Universidade-Empresa no Brasil e o " Argumento da Hélice Tripla". *Revista Brasileira de Inovação*, v. 2, n. 2, p. 267, 2003. Available at: <http://periodicos.sbu.unicamp.br/ojs/index.php/rbi/article/view/8648874>. Last accessed on 18th Octobre 2019.

DAGNINO, R.; THOMAS, H. Planejamento e Políticas Públicas de Inovação: em direção a um marco de referência latino-americano. *Planejamento e Políticas Públicas*, v. 0, n. 23, 10 2009. ISSN 01034138. Available at: <http://www.en.ipea.gov.br/ppp/ index.php/PPP/article/view/76>. Last accessed on 22th Octobre, 2019.

D'ESTE, Pablo; PATEL, Pari. University–industry linkages in the UK: What are the factors underlying the variety of interactions with industry?. *Research policy*, v. 36, n. 9, p.1295-1313, 2007.

EDQUIST, C. *Systems of Innovation: Perspectives and Challenges*. In: FARGERBERG, J.; MOWERY, D.; NELSON, R. (Ed.). The Oxford handbook of innovation. New York: Oxford University Press, 2005. Available at: <http://oxfordhandbooks.com/view/10. 1093/oxfordhb/9780199286805.001.0001/oxfordhb-9780199286805-e-7>. Last accessed on 14th Octobre, 2019.

ETZKOWITZ, H. The triple helix of university-industry-government implications for policy and evaluation. [S.l.]: SISTER Working Paper 11, 2002.

_____. *Hélice tríplice – universidade-indústria-governo: inovação em ação*. Porto Alegre: EDIPUCRS, 2009.

ETZKOWITZ, H.; LEYDESDORFF, L. The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy*, North-Holland, v. 29, n. 2, p. 109–123, 2 2000. ISSN 0048-7333. Available at: <https://www.sciencedirect.com/science/article/abs/pii/ S0048733399000554>. Last accessed on 13th Novembre, 2019.

FREEMAN, C. The economics of technical change. *Cambridge Journal of Economics*, Oxford University Press, v. 18, n. 5, p. 463–514, 10 1994. ISSN 1464-3545. Available at: <https://academic.oup.com/cje/article/1671013/The>. Last accessed on 17th Octobre, 2019.

FRÉZARD, F.; *Evolução do Mestrado Profissional em Inovação Tecnológica e Propriedade Intelectual*. 2019. 19 slides.

KLEVORICK, A.; LEVIN, R.; NELSON, R.; WINTER, S. On the sources and significance of interindustry differences in technological opportunities. *Research Policy*, v. 24, n. 2, p.185-205, 1995.

LALL, S. *Building Industrial Competitiveness in Developing Countries*, Vol. 1. Paris, France, 1990: Development Centre Studies, OECD.

LAPERCHE, B. *The four key factors for commercialising research: the case of a young university in a region in crisis*. OECD Higher Education Management and Policy, 14(3), 149– 173, 2002. Available at <http://www.oecd.org/dataoecd/22/2/ 37444681.pdf#page=146>, last accessed 13 May 2019.

LUNDVALL, B. A. Introduction. In: LUNDVALL, B. A. *National Systems of Innovation: towards a Theory of Innovation and Interactive Learning*. London: Printer Publishers, 1992.

_____.*The university in the learning economy*. [S.l.]: DRUID Working Paper 6, 2002.

_____. *Higher education, innovation and economic development*. [S.l.], 2007.

LUNDVALL, B. A.; BORRÁS, S. *The globalising learning economy: Implications for innovation policy*. Report to the Commission of the European Union, 1997.

MAZZOLENI, R. Catching up and academic institutions: a comparative study of past national experiences. *Journal of Development Studies*, v. 44, n. 5, p. 678-700, 2008.

MAZZOLENI, R.; NELSON, R. Public research institutions and economic catch-up. *Research Policy*, v. 36. p. 1512-1528, 2007.

MOKYR, J. *The Lever of Riches, Technological Creativity and Economic Progress*, Oxford, UK: Oxford University Press, 1992.

_____. *The Contribution of Economic History to the study of Innovation and Technical Change: 1750-1914*. Prepared for the Handbock of the Economics of Technical Change. Tel Aviv, 2008.

_____. The Intellectual Origins of Modern Economic Growth," [Presidential address], *Journal of Economic History* Vol. 65, No. 2 (June), pp. 285-351, 2005.

MONCK, C. S. P. et al. *Science parks and the growth of high technology firms*. London: Routledge, 1990.

MOWERY, D.; NELSON, R.; SAMPAT, B.; ZIEDONIS, A. *Ivory tower and industrial innovation: university-industry technology transfer before and after the Bayh-Dole Act*. Stanford: Stanford University, 2004.

_____. *Universities in National Innovation Systems*. The Oxford Handbook of Innovation. 10.1093/oxfordhb/9780199286805.003.0008. Available at: <https://www.researchgate.net/ publication/264868681_Universities_in_National_Innovation_Systems/citation/download>. Last accessed on 16th Octobre, 2019.

NARIN et al. The increase linkage between U.S. technology and public science. *Research Policy*, v 26, p. 317-330, 1997.

NELSON, Richard R. Capitalism as an engine of progress. *Research policy*, v. 19, n. 3, p.193-214, 1990.

NORTH, D. C. *Institutions, Institutional Change, and Economic Performance*. Cambridge: Cambridge University Press, 1990.

PARANHOS, Julia; HASENCLEVER, Lia; STEINER, Fernanda. Abordagens teóricas sobre o relacionamento entre empresas e universidades e o cenário brasileiro. *Revista Econômica*. 20. 10.22409/economica.20i1.p387, 2018. Available at <https://www.researchgate.net/publication/329383412_Abordagens_teoricas_sobre_o_relacionamento_entre_empresas_e_universidades_e_o_cenario_brasileiro>. Last accessed on 13th Octobre, 2019.

PAVITT, K. Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, North-Holland, v. 13, n. 6, p. 343–373, 12 1984. Available at: <https://www.sciencedirect.com/science/article/abs/pii/0048733384900180>. Last accessed on: 18th Octobre, 2019.

PORTER, M. *The Competitive Advantage of Nations*. New York: Free Press, 1990.

RAPINI, M. S.; CHIARINI, T.; BITTENCOURT, P.; CALIARI, T. *The Intensity of Private Funding and the Results of University? Firm Interactions: The Case of Brazil*. Innovation & Management Review, 2019.

REINERT, E. *How Rich Countries got Rich and Why Poor Countries Stay Poor*. London, UK: Constable, 2007.

RODRIK, D. *One Economics, Many Recipes: Globalization, Institutions, and Economic Growth*. Princeton, NJ: Princeton University Press, 2007.

ROSENBERG, N. Why do firms do basic research (with their own money)? *Research Policy*, North-Holland, v. 19, n. 2, p. 165–174, 4 1990. ISSN 0048-7333. Available at: <https://www.sciencedirect.com/science/article/abs/pii/0048733390900469>. Last accessed on 17th Octobre, 2019.

_____. Scientific instrumentation and university research. *Research Policy*, v. 21, n. 4, p. 381-390, 1992.

_____. *Por dentro da caixa preta*. Tecnologia e Economia. Campinas: Editora da Unicamp, 2006.

SCHWARTZMAN, S. *Formação da comunidade científica no Brasil*. São Paulo: Nacional, 1979.

SUZIGAN, W.; ALBUQUERQUE E. M. *A interação entre universidades e empresas em perspectiva histórica no Brasil*. Texto para discussão nº. 329. Cedeplar, 2008.

_____. The Underestimated Role of Universities for the Brazilian System of Innovation. Brazilian Journal of Political Economy 31 (1): 3–30. 2011.