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„Analysis of the International Cooperation for the Innovative Development: Case study about the INCOBRA Project“

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ABSTRACT

With the ever-growing push towards a "knowledge-based economy", knowledge has become an important aspect when considering the productive processes of enterprises and it has even started to take a fundamental role in economic development. The following thesis aims to analyze various push and pull factors that hinder and/or motivate the participation of Brazilian ST&I actors in European R&D cooperation programs, specifically analyzing FP7 and Horizon 2020. The strategies for R&D internationalization of select European countries, of the European Union as a whole as well as the Brazilian strategy for R&D were analyzed. Long-term tendencies, goals, potential partners and priority fields that are a priority for international cooperation were all taken into consideration. This thesis is based on a questionnaire sent to Brazilian ST&I institutions who participate in national calls for R&I and are registered in FINEP's database. This survey was forwarded to 1,845 Brazilian ST&I institutions, of which 481 answered questions about the barriers and motivations that affect and could potentially enhance the Brazilian participation in Horizon 2020. The main findings of this research were that there is a lack of information and a lack of financial resources, which negatively affects their participation in Horizon 2020. Enterprises are specifically affected by the nature of difficulty when it comes to accessing information about such programs as well as by the difficult technical language that is used to describe them. Funding opportunities do not cover all the aspects of the research process of R&I, such as personnel costs, and present a further barrier for organizations. Brazilian ST&I institutions are also no longer part of the EU's automatic funding and thus suffer due to the lack of funding opportunities. Furthermore, the European programs are too competitive and most participants indicated that an important reason for lower participation was due to the lack of time they had in preparing a competitive proposal. The research also identified that different types of organizations define barriers and priorities differently when it comes to international cooperation. Ultimately, if increased participation in Horizon 2020 is desired by the Brazil government and the European Union, a public policy elaborating measures that are targeted to specific groups must be introduced.

ZUSAMMENFASSUNG

Mit dem Aufstieg der "wissensbasierten Wirtschaft", ist Wissen ein wichtiger Faktor im Produktionsprozess von Unternehmen geworden und stellt eine grundlegende Rolle für die wirtschaftliche Entwicklung dar. Die folgende Arbeit zielt darauf ab Push- und Pull-Faktoren zu analysieren, die die Beteiligung der brasilianischen ST&I Akteure in der europäischen F&E-Kooperationsprogrammen verhindern und/oder motivieren. Die Strategien für F&E-Internationalisierung von ausgewählten Ländern der Europäischen Union und die brasilianischen Strategien wurden analysiert, mit dem Ziel langfristige Tendenzen, Ziele der potentiellen Partner und wichtige Bereiche zu erkennen, die Priorität für die internationale Zusammenarbeit haben. Diese Masterabeit basiert auf einem Fragebogen, welcher an brasilianische ST&I Institutionen geschickt wurde, die an F&E teilnehmen und in der Datenbank des FINEP registriert sind. Diese Umfrage wurde weitergeleitet an 1845 brasilianischen ST&I Institutionen, von denen 481 Fragen über die Barrieren und Motivationen beantwortet haben, die möglicherweise die brasilianische Beteiligung an Horizon 2020 verhindert haben oder motivieren konnten. Die wichtigste Erkenntnis dieser Forschung ist, dass die fehlenden Informationen und der Mangel an finanziellen Ressourcen die Beteiligung in Horizont 2020 negativ beeinflussen. Informationen sind schwer zugänglich und die schwer verstehbare technische Sprache wurde kritisiert. Fördermöglichkeiten im Rahmen von R&I decken Bereiche außerhalb der Forschung, welche als wichtig angesehen werden, nicht ab. Brasilianische ST&I Institutionen sind nicht mehr Teil der automatischen Finanzierung der EU und leiden an einem Mangel an Finanzierung. Die europäischen Programme sind äußerst kompetitiv und die meisten Teilnehmer meldeten einen Mangel an Zeit, welcher es ihnen nicht erlaubte einen wettbewerbsfähigen Vorschlag vorzubereiten. Die vorliegende Arbeit hat darüber hinaus identifiziert, dass unterschiedliche Arten von Organisationen Barrieren und Prioritäten unterschiedlich definieren. Daher sollte eine effektive öffentliche Politik gezielte Maßnahmen setzen, um die brasilianische Beteiligung in Horizont 2020 zu erhöhen und die Barriere einer Teilnhame für bestimmte Gruppen zu überwinden.

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1. INTRODUCTION

1.1 Research theme and research problem

With the rise of “knowledge-based economy”, knowledge has become an important input into the productive processes of enterprises. As aggregate enterprises form an important part of a macro-economy, innovation and Research & Development (R&D) policies assume a strategic role on the technological development and ~~on~~ industrial policy for economic development. Knowledge from entrepreneurial and academic sources combine to transform themselves into innovative products and processes. R&D and Innovation processes derive from many sources and actors, such as: a) entrepreneurial investment on internal R&D; b) R&D cooperation among enterprises, universities and research institutes; c) as well as from public funding through ministries, strategic development banks, laws, etc.; and are part of a specific system of innovation. The innovative process is, therefore, the result of collective action, involving many actors and develops itself based on these dynamic interactions.

The global configuration of gross expenditure on R&D and innovation processes are strongly concentrated within the triad USA, Japan and the European Union (EU). This scenario became to change in the early 2000’s, when the BRICS’s rise began a process of counterbalancing the hegemony of the USA, Japan and the EU as Research and Innovation (R&I) superpowers. On the other hand, the rising transnational financial flows directed to R&D activities reshaped a new geography, which until then were composed hegemonically by countries of the USA-Europe-Japan triad. This shift made the rise of emerging countries such as China, India, Brazil, Saudi Arabia, etc. possible, who too began to be net receivers of transnational financial flows for R&D. (OECD, 2008; RUIZ, 2015; ZUCOLOTO; CASSIOLATO; 2013)

The EU, among the hegemonic countries, however, loses relative presence in the international cooperation with major research countries in Asia, specifically China, but maintains its importance as an international partner with Japan and South Korea. (COM, 2012, p. 4) The growing relevance of emerging economies in the global R&I scenario enhances the willingness of the leading countries in R&I to invest in these processes in order to not lose their relative position in the global economy. International cooperation, therefore, gains space in the international policy, as the BRICS gain relevance in the international R&I scenario. Emerging economies have taken a large step towards solidifying their National Innovation Systems and institutions – as recognition of the importance of knowledge-based economies – and are gaining relevance in todays R&I activities internationally.

From another perspective, emerging economies have taken a large step towards solidifying their National Innovation Systems and through trying to foster learning processes. Through this, they are fostering their absorption capabilities and are gaining relevance in today's R&I activities internationally. Challenges must be confronted with a national ST&I policy, i.e. directing R&I activities to solve societal problems, specializing in learning by solving (see AROCENA; SUTZ, 2010). Improving the knowledge base by systematically using advanced information for solving problems is called *learning by solving*. It takes place regarding knowledge demand, aiming to minimize learning divides – international hierarchical structure, historically constructed (AROCENA; SUTZ, 2010).

The European Commission's strategy for R&I is cooperating internationally, in order to regain the relative domain in the international scenario. This thought is the result of a diagnosis of the *knowledge-based economies* as a new paradigm and an important input into the productive process, as well as the complementary, instead of adverse/contrary, character of knowledge. (COM, 2012; COM, 2012a) In this context, emerging economies gain terrain in international R&I cooperation policies, as both sides take part in a win-win R&I strategy. Instruments to reach these objectives are programs such as the seventh Framework Program for R&D International Cooperation and Horizon 2020. This was implemented by the EU with the aim to improve international cooperation within the European Union (the so called *Europeanizing* R&D investment). It was hoped that this program would allow knowledge to be shared, ultimately promoting interaction with the best R&I actors to fight global challenges.

The goal of this thesis is to analyze push and pull factors that hinder and/or motivate the participation of Brazilian ST&I actors in European R&D cooperation programs, such as the 7^{th} Framework Program for R&D and Horizon 2020. The importance of this theme lies within the recent introduction of H2020. The recent exclusion of Brazilian actors from the criteria of automatic funding in H2020 and lastly the recent efforts of the Brazilian government to foster Research & Development (R&D) and Innovation inspired by the potential opportunity of the home country profiting from the internationalization of R&D. It is the combination of these important aspects that increases the relevance of this particular research.

1.2 Objectives

In this following research, the barriers and motivations of Brazilian ST&I actors to participate in European R&D programs, FP7 and H2020, are going to be analyzed. A quantitative, as well as qualitative, analysis will investigate three major aspects of Brazilian institutions that participate in Brazilian national calls for ST&I projects. First, characterizing the profiles of such actors, secondly, analyzing the barriers that hinder participation to participate in EU's R&D cooperation programs and thirdly, investigating the potential of these actors to participate and increase their participation in H2020.

1.2.1 General Objective

The goal of this thesis is to analyze push and pull factors that hinder and/or motivate the participation of Brazilian ST&I actors to participate in the European R&D cooperation programs.

1.2.2 Specific objectives

This empirical work is embedded in a theoretical framework, which involves an introduction to the Schumpeterian and Neoschumpeterian theoretical approaches on innovative development and internationalization of Research and Development (R&D) to contextualize the ontological framework being worked on. Furthermore, the EU strategy for R&D internationalization and those of selected countries (Germany, Italy and Spain) – as well as the Brazilian strategy for R&D internationalization – will be characterized to understand the broader political and economic context, in which this study is situated. Finally, this study's empirical investigation will analyze the barriers and motivations of Brazilian ST&I actors that take part in national calls for R&D projects, but do not take part in EU's R&D cooperation programs, which is the target group. This analysis is based on a survey directed to the target group, whose results will provide information about push and pull aspects for participating in EU's seventh Framework Program for R&D and H2020.

1.3 Methodology

This research is a case study with bibliographic review supplemented by a survey. The goal is to analyze push and pull factors that hinder and/or motivate the participation of Brazilian ST&I actors in the EU's R&D cooperation programs – FP7 and H2020. In order to achieve the research objective, this work was divided according to specific analytical criteria.

First, an introduction to the Schumpeterian and Neoschumpeterian theoretical framework will be based on a bibliographical review, to provide a theoretical base to the subsequent arguments. This section focuses on pertinent works of Schumpeter, Freeman, Nelson & Winter, Ana Urraca Ruiz, Zucoloto e Cassiolato, among others. The focus will be to expose the economic approach of innovation economics, economic cycles (as an endogenous aspect of the economic system) and the main role of technological development as a main cause of continuous disturbances of the system. Thereafter, the main concepts of the Neoschumpeterian approach will be presented in an evolutionary approach to economics, dealing with national innovation systems, learning processes, absorption capabilities, among others, aiming to achieve an economic explanation for the importance of R&D and its internationalization process.

This argumentation is followed by a documental and bibliographical review, which characterizes the strategies of selected European countries concerning the internationalization of their R&I processes. Reports by the European Commission, documents published by the ministries of selected countries and the EU, as well as academic studies ground this documental and bibliographical review.

In addition to the previous point, an analysis of documents of the Brazilian Ministry for Science Technology and Innovation, such as the National Strategy of Science, Technology and Innovation 2016-2019, the National Strategy of Science Technology and Innovation 2012-2015 and its precedent Action Plan for Science

Technology and Innovation 2007-2011. This section focuses on characterizing the Brazilian strategy for R&D internationalization.

In particular, such document research will be done in order to describe FP7 and H2020. Documents such as the FP7 monitoring reports as well as B.BICE+ reports and studies are the basis of this part of the research.

Finally, a semi-structure questionnaire was elaborated under the definition of Boni & Quaresma (2005) and Manzini (2004) of a set of pre-defined questions, based on theories and hypothesis that relate of the research theme, in order to obtain a better sample of the target population. The questionnaire was sent as an online survey applied to the target group (Brazilian actors that take part and/or have taken part in calls for national R&D projects) will provide this research with important information concerning the barriers and motivations of Brazilian ST&I actors for submitting applications to take part in FP7 and/or H2020.

2. THEORETICAL APPROACH

2.1 Introduction

The detailed presentation of the theoretical approach, which constitutes the basis for this analysis, is fundamental for the comprehension of innovative processes. The goal of this chapter is to present the meaning and characteristics of the innovative process and the transmission of its effects onto socioeconomic development.

An understanding of the Neoschumpeterian approach is only possible if, prior to that, a short introductory part of this chapter is dedicated to the Schumpeterian approach.

2.2 Schumpeterian Approach

Joseph Schumpeter dedicated his academic life to trying to understand economic development as a critique to the traditional theory of economic development, the mainstream positivist economic theory. In mainstream economics, the current data is constantly adapted and fall into a circular flow, through which the economic system tends to converge towards an equilibrium. The Schumpeterian approach proposes a new interpretation to dynamic systems, in which the economic agents have limited rationality and the circular flow is constantly disturbed by irrationality, information asymmetry, uncertainty, etc. The consequence is that such an economic system by itself is dynamic, in constant change and does not reach a point of equilibrium.

The economic agents interpret the economic data and their behavior as a dynamic process, rather than static. The main point in this approach is the discontinuity of the circular flow and that new combinations in the production process are under constant adaptation. The behavior of any economic agent in this theory will contrapose, in all senses, the economic agent assumed by the traditional economic theories. (SCHUMPETER, 1982) Following the author's words, development "consists of a form of employing different resources in different ways, as long as new results come out of the production process", as a different production process not employed before in the economic system, and proceeds, "independently if savings and investment grow or decrease during this process”. (SCHUMPETER, 1982, p.50) In other words, independently from the financial results, the different combinations, the new arrangements of resources in the economic activity are characterized as such.

Insofar that the new combinations appear discontinuously, development takes place. Development, as a Schumpeterian concept, involves five aspects. The first consists of the introduction of a new product; the second, the introduction of a new method; the third, the access to a new market; the fourth, access to a new source of natural resources of semi manufactured goods; the fifth, the new organization of an existing industry. (SCHUMPETER, 1982)

These above-mentioned aspects are the main characteristics of what Schumpeter (1982) means by *new combinations* – spontaneous changes in the economic system –, which are introduced in the circular flow by a Schumpeterian Entrepreneur, causing constant disturbances to the point of equilibrium.

Economic development is a phenomenon that takes place inconsistently and disturbs the tendency towards equilibrium. It appears discontinuously in the many economic spheres, causes changes in the channels of the flow, alters forever the tendency towards equilibrium, displaces it from its previous state and has as main disturbing agent: the entrepreneur. (SCHUMPETER, 1982)

A second divergence deals with the interpretation of the origin of necessary resources for new productive processes. For the orthodox, the necessary resources for making future investment possible arises from savings taking place during the ongoing production process. Mainstream economics assert that future investment originate from aggregate savings that can be taken out of production and allow investment in the next period. Instead, Schumpeter argues that, savings provide resources for investment not from avoiding consumption, but rather that savings originate from successful innovation results of a previous period. Saving originates only from a successful innovative activity, which produces realized profits that happened in the previous period, that is, originates from the *entrepreneurial profit*. In the circular flow, there would not be such a rich source of savings. (SCHUMPETER, 1982)

Entrepreneurial profit emerges as a concept from the entrepreneurial activity. Entrepreneurs go through high risks and difficulties when initiating a new activity and the results of this risky activity is a reward: profits above average – the most attractive incentive for being protagonist of economic development, entrepreneurial profit. (SCHUMPETER, 1982)

However, in the absence of such resources, originated in the previous period, there is a second factor that provides development: *the credit*. An economic agent with no access to economic means realized in the previous period – and thus unable to adventure into new combinations – has in the banks – through their capacity in generating purchase power – his main financial sources for promoting new combinations. Therefore, through credit, economic agents have their first opportunity to promote development and consequently foster their future innovative activities. (SCHUMPETER, 1982)

What differentiates business persons from one another are their activities. Where and how they act arises the relevance of a new concept: *entrepreneurship*. It is simple and of objective definition: "We call 'entrepreneurship' the realization of new combinations; we call 'entrepreneurs' the agents whose function is to promote new combinations." (SCHUMPETER, 1982, p. 54) Entrepreneurship is not a trivial activity. It involves a series of difficulties an entrepreneur has to face during the decision-making process: a) the difficulty of obtaining data and numbers to base the decision-making; b) the entrepreneur's psyche; c) the reaction of the socioeconomic environment to innovation, that is, its regulating forces. (SCHUMPETER, 1982)

Finally, there are three main oppositions to the traditional theory of economic development that can be briefly summarized. To begin, the opposition to the circular flow and to the tendency into a general equilibrium, supposing there are changes in the channels of the flow, affecting the economic routine, or else, changes of the economic data that emerge within the system. Secondly, the preponderancy of the dynamic over the static as well as, the divergence on the peculiar qualities that defines a manager and an entrepreneur.

The Schumpeterian idea of development, as briefly explained above, evokes significant implications to the consecutive course of the economy. The entrepreneurial economic agent inserted in the dynamics of the channels of economic routine – disturbing irregularly the channels of the flow – is extremely relevant as a contraposition to the traditional economic analysis, based on trends towards a general equilibrium. The economic environment becomes unstable, uncertain and, therefore, *cyclical*. (SCHUMPETER, 1982)

Development does not occur, however, uniformly, continuously and uninterrupted. It is composed of mischance, accidents, and movements that obstruct the ways in which development takes place. Mischance is frequent in economic activity – endogenous or exogenous to the economic activity – and thereafter, is capable of hindering development, or even, making it impossible. Hence, development is an interrupted continuity that initiates opportunities for new economic agents to emerge, promoting new combinations of resources resultant from the economic activity. (SCHUMPETER, 1982)

Schumpeter (1982) emphasizes the interrupted continuity; that some development phenomena stands out in relation to others. However, as explained above through the non-continuous character of new combinations the economic activity has the instability of its movement as an intrinsic character of its functioning. Successive ups and downs of economic activity (adaptation process of the economy to new settings) is a relevant characteristic of development referred to as, *booms* and *crisis*. Development is interpreted as the disturbance of socioeconomic environments, emerging from entrepreneurship, and whose actors are pushed by the entrepreneurial profit. The appearance of the entrepreneur is not continuous either. They appear in groups and this phenomenon is one of the causes of the economic *boom*. (SCHUMPETER, 1982)

Concerning the unpredictable appearance of new combinations, three interpretative elements must be stressed. First, they do not originate from old businesses, nor substitute immediate old forms of production. On the contrary, new combinations arise along with old combinations and compete with one other. Second, entrepreneurial demand appears in masses, which causes a substantial increase in business purchase power, a secondary boom, causing industrial spills-overs in the economic system, resulting in general prosperity. Third, considering that the goal to be followed is the enlargement of an economic activity, consisting on new combination of resources not yet experimented, economic errors perform an important role in the beginning of the boom and in the course to its inflection. (SCHUMPETER, 1982)

A more elaborate exposition of the theoretical approach, with focus on the Neoschumpeterian approach, aiming to explain the internationalization of Research and Development processes, is going to follow in the larger version of this project, as it continues and develops into the master thesis.

2.3 Neoschumpeterian Approach

> *"A critical history of technology would show how little any of the inventions of the 18th century are the work of a single individual. Hitherto there is no such book. Darwin has interested us in the history of Nature's Technology, i.e., in the formation of the organs of plants and animals, which organs serve as instruments of production for sustaining life. Does not the history of the productive organs of man, of organs that are the material basis of all social organization, deserve equal attention? And would not such a history be easier to compile, since, as Vico says, human history differs from natural history in this, that we have made the former, but not the latter? Technology discloses man's mode of dealing with Nature, the process of production by which he sustains his life, and thereby also lays bare the mode of formation of his social relations, and of the mental conceptions that flow from them."* (MARX, 2008)

The Schumpeterian approach, as any other, is the synthesis of a certain historical momentum, in which it emerges. In this context, we can infer that since Schumpeter's Theory of Economic Development was published, many aspects concerning the functional aspects of economy and national societies have changed. These changes bring the necessity for the insertion of new analytical elements in the economic theory, in order to narrow economic theory to a constant mutating socioeconomic reality. Many theoretical gaps have been filled since Schumpeter's work, leaving a fertile ground for the Neoschumpeterian to develop a more complex understanding of development, following the evolution of philosophy, science and economics. Therefore, an exposition of the main concepts introduced by a Neoschumpeterian approach is more than necessary.

Shortly before that, it is of significant importance explain some basic concepts. Research & Development (R&D), for example, is going to appear often as an important concept that plays an important role in innovative processes. R&D can be defined as a creative task executed systematically, aiming to give answers to scientific challenges and technological uncertainties, which are able to allow for the improvement and utilization of human knowledge, resulting in new use of knowledge and techniques and is beneficial to society. R&D is not the only factor that allows for the emergence of innovations:

learning processes applied in functional and organizational activities is also a very important source for firms. (COSTA et al, 2012)

Moreover, R&D activities are classified in: a) *basic research* – destined to acquire more knowledge about a subject, whose application opportunities are still unknown; b) *applied research* – which aims to relate and apply known concepts, in order for the application of a new product or process to satisfy a certain market necessity, and; c) *development* – defined as a systematic use of acquired knowledge during short-term research, aiming to produce better materials, devices, systems or working methods. (COSTA et al, 2012)

Back to the theoretical contraposition: as Schumpeter, the Neoschumpeterian assume a strong position objecting the neoclassical interpretation of socioeconomic phenomenon. The Neoschumpeterian oppose firmly: a) that firms are capable of making optimal decisions; b) that the economic agents are completely rational and; c) that the stochastic nature of socioeconomic development becomes relevant. These three aspects express the divergence on the behavioral understanding of economic agents and organizations regarding the qualitative evaluations of economic and organizational processes. There is no intelligibility *ex-ante* about the best decision, the best searching methods, the best selection models and which technology to adopt. It is assumed that the decision-maker does not know *ex-ante* the characteristics of a non-existing technology and that the decision-maker acts under uncertainty. However, he knows some determined technical characteristics that allow him to categorize a set of possibilities in classes and subclasses. (NELSON; WINTER, 2005)

For this reason, it is very important to understand thoroughly searching, selection and organizational routine processes. These are vital in understanding the process of decision-making in the firm, focusing on uncertainty during the decision-making, non-rationality of economic agents and the stochastic nature of this process. Thereafter, the Neoschumpeterian approach positions as a critique to two ontologies assumed by some mainstream approaches of innovation economics. The mainstream classifies as two the determinants of technologic progress: the *demand-pull* and *technology-push*.

By demand-pull, it is understood that the market forces, through utilitarianism, the satisfaction of markets' needs, its feedback and the relation of markets' needs with a firm's research staff determine technological change. That is, technological change emerges as a response to a group of researchers in a firm dedicated to research and set their efforts in overcoming a firm's difficulties in the market. The main idea in this hypothesis is that innovations are the response to profitable opportunities. If so, growing industries have more innovative activities than stagnated industries. This logic happens, because growing industries mostly need additional capital goods, which promotes profitable opportunities to the suppliers of these sophisticated machines and creates an incentive to innovate – under the understanding of this approach. There are some implications to this approach: large firms with higher installed capacity to promote research have advantages over those who have less sophisticated research infrastructure. In addition, a large firm with a large variety of products can dispose of more opportunities to identify profitable opportunities through innovation. (KAMIEN; SCHWARZ, 1982)

On the other hand, technology-push understands technological progress as an exogenous factor, that is, it is a variable autonomous to economic development. Under this approach, it is the responsibility of the firm's research staff to undertake innovation. Advances in the scientific basis are brought to market through a firm's research staff. There are two implications concerning this hypothesis. First, a firm with a larger infrastructure and resources for research has advantages over another firm, once its group of researchers has a wider capability of identifying a potential scientific basis that can have a commercial use. Second, the pace of innovative activities will depend on advances in the scientific basis, that is, in areas in which the scientific basis is stationary, the innovative pace tends to be much slower than in those areas, in which the scientific basis develops faster. (KAMIEN; SCHWARZ, 1982)

Both approaches have a complementary instead of an exclusive character. The difference is that the first approach is a *short-term* interpretation, while the second is a *long-term* understanding of technical progress. These approaches, however, present some limitations, which are criticized by Neoschumpeterians.

First, Neoschumpeterians criticize that both approaches have a passive and mechanical concept of technological change, related to market conditions. Secondly, they are incapable of explaining why certain technologies are selected instead of other available technologies. Thirdly, there is a neglect of intertemporal changes in innovative processes, which do not have any direct relation to changing market conditions (DOSI, 1984; DOSI, 1988; NELSON; WINTER, 2005; FREEMAN; SOETE, 2000). All in all, the Neoschumpeterian approach has a less mechanical and more systemic approach to innovative processes.

2.3.1 Technological paradigm and technological trajectories

It is important to stress technological innovations do not emerge *per se*. This idea is opposed to the natural aspect and constant pace that the traditional theories believe. There is a strong link between science and technology and the way to interpret the phenomenon of technical progress – which infers that this phenomenon is inseparable from science and knowledge production. Paradigms, as a concept, appear from a contribution by Thomas Kuhn to the philosophy of science and its demarcation criteria. From Thomas Kuhn emerges the first adaptation of this concept of science to technology: the concept of scientific paradigm (scientific research programs) (KUHN, 2009) was extended to include the concept of technological paradigm (technological research programs). (DOSI, 2006)

Scientific paradigm is a term strictly related to normative science. The scientific praxis provides models, from which traditions arise and are coherent and specific to its scientific research. (KUHN, 2009) In a broader sense, scientific paradigm is a dominant research program – a dominant convention – over the other existing programs.

> "The study of paradigms (…) is what mainly prepares the student for membership in the particular scientific community with which he will later practice." (KUHN, 2009, p. 30)

Moreover, the author continues:

> "Men whose research is based on shared paradigms are committed to the same rules and standards for scientific practice. That commitment and the apparent consensus it produces are prerequisites for normal science, i.e., for the genesis and continuation of a particular research tradition." (KUHN, 2009, p. 30)

Scientific paradigm is a perspective that expresses relevant problems, an inquiry model or inquiry standard. (DOSI, 2006) Groups of scientists that are under the same inquiry program, under the same norm, follow the same scientific paradigm. This concept, however, can be easily adapted to a *technological paradigm*, according to Dosi (2006, p. 14):

> "We shall push the parallel further and suggest that, in analogy with *scientific paradigms* (or scientific research programmes); there are '*technological paradigms*' (or technological research programmes)"

The technological paradigm defines, in a certain context, the socioeconomic needs to be satisfied, the scientific principles necessary for this task, as well as the technology that should be used. In these terms, a paradigm is a set of procedures that orient the investigation on a technological problem. It defines the context, the investigation goals and defines the resources to be used. (CÁRIO, 2012)

Therefore, a technological paradigm is "a 'model' and a 'pattern' of solution of *selected* technological problems, based on *selected* principles derived from natural sciences and on *selected* material technologies." (DOSI, 1984, p. 14) The similarities between both concepts allow the conceptual adaptation of the term scientific paradigm to technological paradigm, as well as it allows the relation of the conceptual boundaries between both. Exactly as the concept of scientific paradigm serves science defining the research area, it also serves technology defining the pace of technological research, in other words, defines its trajectory.

Contrary to demand-pull and technology-push, Neoschumpeterians see in the technological paradigm the phenomenon that defines technical change and that consequently define the technological trajectory. The technological trajectory is the direct result of a complex selection process of countless possible trajectories of technical change under a technological paradigm. According to Dosi (1984, p. 14-5) "as 'normal science' is the actualization of a promise contained in a scientific paradigm, so is 'technical progress' defined by a certain 'technological paradigm'."

Finally, technological trajectory can be defined as a standard activity following a normative procedure of problem solving (towards the development), based on a technological paradigm. (DOSI, 2006) In other words, according to Kupfer & Hasenclever (2002), the technological trajectory is the intertemporal endogenous evolution of industry, through innovation and its selection through the market, through the industrial structure, through technologies, market share and market concentration.

As mentioned above, technological trajectory is the standard determined by the technological paradigm and the result of a complex selection process or countless possibilities (or else the multidimensional movements among the technological variables defined as relevant for the paradigm).

However, the technological paradigm defines technological trajectories as a series of characteristics, which according to Dosi (1984, p. 17-8) are:

1. There might be more general and more circumscribed as well as more powerful or less powerful trajectories;
2. These are generally complementarities between different forms of knowledge, experiences, skills, etc. Furthermore, developments or lack of development in one technology might foster or prevent developments in other technologies;
3. In terms of our model, one can define as the *technological frontier* the highest level reached upon a technological path with respect to the relevant technological and economic dimensions;
4. It is likely that progress on a technological trajectory retain some cumulative features: the probability of future advances is in this case related also to the position that one (a firm or a country) already occupies *vis-à-vis* the existing technological frontier, which is going to be thoroughly detailed next;
5. When a trajectory is very powerful, it might be difficult to switch to an alternative one;
6. It is doubtful whether it is possible to *a priori* compare and assess the superiority of a technological path over another. There might indeed be some objective criteria, once some indicators are chosen, but only *ex-post*. (DOSI, 1984) This item matches ~~to~~ Kuhn's principle of incomparability and immeasurability principles between different research programs. (KUHN, 2009)

It is important to stress that a technological paradigm is not an exclusive and absolute normative program. It coexists with other research programs, however, the paradigm is the convention accepted by a majority that have influence in the area. Thus, technology includes the perception of a limited set of possible technological alternatives and of notional future developments (DOSI, 1984, p. 14)

2.3.2 Innovative procedures

A firm's behavior is evidently explained by the context of constant attempts to apply change to its products, to its methods and production and commercialization processes, insisting on an eternal profit chase. Nevertheless, the attempt of constantly improving its technological capability, in order to improve its productive efficiency is of a high uncertainty level. That is, assuming the decision-maker does not know the characteristics of the not yet invented technologies, does not know the results and profits followed by the introduction of this respective technology and either the exact investment costs, nor the hypothetically unknown variables.

In this context, there are three concepts to be explored, in order to understand a firm's behavior seeking the innovative process: *search*, *routine* and *selection*. Taking into consideration the evolutionary economic theory, there are some aspects upon which the competition process is based. First, as evolutionary theory is bounded to biology, the entrepreneur's behavior is similar to the biological process of natural selection. Next, the evolutionary character is a mechanism linking the genotypic level with the entities (*genes*), which undergoes environmental selection. Third, there is some process of interaction, yielding the selection dynamics. Forth, there are some mechanisms generating variations in the population of genotypes and, through that, among phenotypes. The difference among these environments is that technology plays a central role in the intertemporal survival and resistance of a firm in high competitive markets. (DOSI; NELSON; 1994)

> "Precisely because there is nothing which guarantees the optimality of these routines, notional opportunities for the discovery of 'better' ones are always present. Hence also the permanent scope for search and novelty ('mutations'). The behavioral foundations of evolutionary theory rest on *learning processes* involving *imperfect adaptation* and *mistake-ridden discoveries*. This applies equally to the domains of technologies, behaviors and organizational setups." (DOSI; NELSON, 1994)

Furthermore, it is assumed that technological paradigms go through the same search and selection process. Therefore, the technological paradigm, the same that defines a technological trajectory, is selected through specific mechanisms (economic forces, social and institutional factors and structures) and plays a central role in the searching behavior of firms during the innovative process.

2.3.2.1 Search

Firms explore the uncertain paths of innovation process aiming to achieve productivity gains, competitive advantage and market share in relation to its competitors. When deciding to go through an innovative path, firms start searching. Thereafter, firms experiment, develop or imitate new technologies and processes in order to implement it in their products. This is an extremely uncertain process, especially the searching process, once there is no knowledge *ex-ante* of what the outcome and efficiency of a certain technology is going to be. The search for an innovation is the realization of an express task in routine processes, that is, in search for new techniques, firms go through routines. (NELSON; WINTER, 2005)

Still, the search process is not exclusively composed of economic aspects, but a combination of technological and economic attributes. Discovering these attributes is similar to doing research, tests and realizing studies. For economic attributes, for example, they consist of input coefficient or products' attributes. On the other hand, technological attributes comprehend the size of a product, its chemical composition or even its thermodynamic cycle, which does not have any economic character, but its knowledge is essential to the decision-making process on R&D. (NELSON; WINTER, 2005)

Decision-makers follow some decision rules that guide this decision process. These rules determine the *search direction*, which can be denominated as *search strategies*. They depend on many conditions, among which: the firm's size, its profitability, on the competitors' behavior; on the assessment of R&D performance; on categories of particular projects; on the difficulty of reaching certain technological improvements and; the complexity of skills and experience a R&D staff disposes.

Besides, these are conditions that directly affect a firm's behavior, that affect the adopted innovation modality (product, process or organizational innovation), that affect the technological diffusion – and fosters and directs the technological trajectory –, and the innovation pattern – the aggressiveness or passivity adopted by the firm for the innovative process. Finally, it directly influences efforts on R&D.

> “The rationale is that innovative activities are often cumulative, path-dependent processes which puts certain constrains driving firms to pursue R&D along its existing trajectories.” (DOSI, 1984)

As results of the *search process* can be described as two possibilities: invention (technologies not yet invented that are discovered during the process or the further development of an already existing technology) and modification of a firm’s knowledge.

However, in order to reach significant and successful results, three components of search must be followed: its topography, its search activities, and its decision rules. These are going to be components considered to set decision rules, strategies and trajectories taken by the technological progress and revealed by empirical research. (NELSON; WINTER, 2005)

Finally, summarizing briefly the search process, first, the decision-maker disposes of a sample of subpopulations, about which a study is going to be done and its elements are going to be tested. Departing from the results of this study, economic attributes of a new technology start to be taken into account – that is, declining costs due to the introduction of the new technology, or process, in case it is developed. (NELSON; WINTER, 2005)

2.3.2.2 Routine

Routines are likewise of fundamental importance for the evolutionary approach, once it is an important behavioral characteristic of economic agents and organizations, regarding innovative decisions within a highly competitive and selective market. Routines are techniques and processes, through which products are produced and services are done. It can also be referred to as a repetitive standard of an activity in an entire organization, as an individual skill, a regular efficacy and without any incidents on an organizational or individual performance. (NELSON; WINTER, 2005) According to Tigre (1998), routines consist of a behavior determinant to a firm’s success. Once established, routines substitute the necessity of a rigid hierarchy, allowing the decision to be coherent by the individuals who know their task, interpret and respond correctly to a strategic situation.

Furthermore, behavioral standards and rules related to firms are defined as routines. It has an evolutionary character, in the strict biological sense of natural selection of a competitive environment. They are heritable from previous selected routines, due to its cumulative character. In addition, it aims towards maintaining efforts directed to an organizational control, to the reproduction of existing routines and towards the imitation of routines adopted by other organizations.

Besides, it is also relevant to differentiate static and dynamic routines. Static routines refer to the capability of firms to reproduce previously executed activities. On the other hand, dynamic routines consist of learning processes, which improves a firm's capability to incorporate new knowledge and develop new products and processes.

2.3.2.3 Selection

Conceptually, the selection environment determines, assuming a certain innovation regime, the way the relative use of different technologies changes through out time. Selection consists of the choice of the most adequate routine through time, based on the given market technological strategy, resulting in a differentiation among firms. As soon as the results are not satisfactory anymore and a firm loses its competitiveness, it is usually followed by the beginning of a search process for new routines. (NELSON; WINTER, 2005) However, the success of an innovation is directly related to the profitability of a new product, or process, introduced in the market – also highly dependent on the consumers' preference.

When looking at the selection process, two different environments, the market environment and the extra-market environment, directly influence it. The market environment is defined as the selection environment, in counterpart to the extra-market environment, whose characteristic is the uncertainty of the distinction between the firms' and customers' interests

The market as a selection environment is important, because competition establishes the selection rhythm, as long as firms introduce better production methods and products. The first aspect of the selection process is the opportunity of a practical implementation of the technology while the second is the possibility of commercialization and satisfying outcomes. Briefly, based on Schumpeter (1982), the selection process would respect the logics of the entrepreneurs' motivation when deciding to innovate, the *entrepreneurial profit*. It does not mean that every innovation will have successful economic results; many in fact do not. That is, when deciding to innovate, entrepreneurs are taking risks, as they do not know *ex-ante* the outcome of this changing process. Nor are the alternatives to the innovative process clear. In addition to that, the difference between invent and innovate must be clear. To invent means to create a new process, technique or product, i.e. scientific articles, technical articles, patents, etc. To innovate, on the other hand, is to practically introduce an invention into the market.

According to Nelson & Winter (2005), the selection process consists of many elements that directly influence a firms' behavior:

a) The nature of the benefits and costs considered by organizations and the firm that decide whether or not to adopt an innovation or not;
b) The way in which consumers' preferences and laws influence the profitability;
c) The relation between profit and expansion/contraction of certain organizations;
d) The nature of the mechanisms, through which firms know about other firms' innovations and the factors that allow/hinder imitation;

Taking into consideration the above mentioned aspects, the selection environment provides outcomes that vehemently influence the R&D activity that firms performing in a determined sector will consider profitable or not. These decision processes depend strongly on the scientific basis and depend on what is known at the moment the searching process begins.

2.3.3 Innovation Patterns

Innovations – as long as innovation is understood as a new combination of production factors – are distinguished by the degree and extensions of the changes occurred in relation to what existed before. There are basically four different degrees concerning innovation: *incremental innovation*, *radical innovation*, *new technological system* and *new techno economic paradigm*.

Incremental innovation is the most elementary and gradual degree of innovation. It consists of small improvements to the product or process. According to Tigre (2006), they embrace design improvements or quality improvements of a product, improvements in layout and processes, new logistic and organizational arrangements, and new sales or supply practices. Incremental innovations also have the characteristic of occurring continuously, independent from the industry; however, it can vary according to many variables related to its sector, region, country and transnational unions.

Radical innovations are defined when the predominant trajectory is broken and a new trajectory redefines innovation activities, causing a considerable productivity rise. Radical innovations are characterized as discontinuous shocks on products or processes' technologies and happen discontinuously though time, sectors, industry branch, etc. (TIGRE, 2006)

Changes in the technological system are occur through many different sectors of an industry and creates new economic activity. (TIGRE, 2006) In these terms, a whole sector is transformed by the introduction of a new technology. Furthermore, according to Tigre (2006), consequence of the introduction of such a powerful technology is the change of organizational practices and a firm's relation to the market.

Finally, the emergence of a new techno economic paradigm affect the economic system as a whole. Its effects regards technical and organizational change (stressing that a paradigm is not exclusively technical), products and processes change, creates new industry branches and establishes long-term innovation trajectories. The paradigm change consists of many incremental and radical innovations, and therefore affects many sectors of the economy. The emergence of successive technological paradigms is responsible for long cycles of economic development. Therefore, there are many conditions for a paradigm change, such as low costs with declining tendencies, apparently unlimited supply and potential to diffuse through many sectors and processes. (TIGRE, 2006)

2.3.4 Technological diffusion

With the emergence of a new technology in the market, it irradiates and disseminates, under a certain rhythm, through the different agents taking part of the market. Conceptually, technological diffusion is the process through which innovation is conveyed via certain channels, through time and through the members of a social system. (ROGERS; SCHOEMAKER *apud* TIGRE, 2006) Diffusion does not happen uniformly over time, once different economic agents decide for different methods of search and selection in different places and under different asymmetrical techno economic factors. According to Tigre (2006), the technological diffusion is responsible for a higher economic impact than that of the innovation itself, once it expresses the adoption of a technology widely by the different sectors of society. The diffusion process can be analyzed through its technological trajectory, diffusion rhythm, conditionality and the impact of a technological diffusion over the economy, society and the environment.

Concerning the process of technological diffusion, it boosts and sets the direction of an innovation's technological trajectory, once the technological diffusion reveals problems that can be solved during the process, in other words, the technological diffusion refers to adopted technical options during the trajectory's evolution. (TIGRE, 2006) There are two mechanisms, through which profitable technology can be diffused. First, the more intensive use of new technology by the firm that brought it to market. Secondly, the launching firm can present a high growth rate, in absolute and relative terms, and attract new investments. The rhythm of technological diffusion is the pace that a society adopts a certain technology – the number of people who adopted a technology in relation to the whole sample of potential users. Thus, "the more a technology is used, the better it becomes vis-à-vis its competitors." (DOSI; NELSON, 1994, p. 166)

Interpreted as a process, technological diffusion was first dealt with by Mansfield *apud* Tigre (2006), who first showed that the temporal evolution of a technology could be represented by a growth function called "Pearl's law". This law represents how technology diffuses and is associated to a regular cycle, in an *S* form, divided into the following stages: introduction, growth, maturation and decline. First, during the introduction there are high uncertainties concerning the innovation's possible benefits. Second, during the growth stage, accumulated knowledge and the technology's performance increases and *follow-ups* such as incremental innovations take place and help the improvement of a respective technology. Third, incremental innovations are less frequent and sales stabilize. Forth, the respective technology starts to be abandoned due to the emergence of new technologies.

Technical, economic and institutional factors influence a technology's diffusion, regarding how the technology is understood as being of easy or difficult application, its acquisition and implementation costs that influence the investment yields and institutional factors (means of financing, trade agreements, intellectual property rights, among others).

Finally, regarding the impacts followed by the diffusion of new technologies, they can be divided into three dimensions: social, economic and environmental. The economic effect consists of changes in, for example, the industrial structure, the level of economic growth, competitiveness among countries and market concentration. The social dimension concerns the impacts technologies have on jobs and the population working conditions. The environmental dimension regards the impact innovation has, positively or negatively, on natural resources, on oceans, rivers, forests, etc. Although many innovations occur aiming to reduce the impact of production on the environment, many do in fact negatively affect nature due to a cumulative environmental degradation.

2.3.5 Learning Processes

> *"The most important resource in the economy is knowledge and the most important process is learning" (LUNDVALL, 2005)*

Knowledge is an essential input in contemporary economies. Knowledge is tacit and cumulative, in other words, path dependent. Thus, the process of knowledge development is very important to understand the innovative processes. Learning processes play an important role in developing knowledge and are the special focus of this section. Coriat & Weinstein *apud* Tigre (1998) define the learning process as "the process in which experiment repetition allows tasks to be executed faster and more efficiently and, therefore, allow new operational opportunities to be experimented."

The continuous and repetitive form of task execution allows for a faster execution, knowledge accumulation, skill improvements, experience augmenting and, most importantly, improves the firm's capability of exploring new technological opportunities.

(CÁRIO, S.; PEREIRA, F., 2001) Therefore, learning improves the R&D staff's prior knowledge and diversity of background, and therefore, the firm ability of exploring existing knowledge, to identify new external information, to assimilate it and to apply it to commercial ends. In other words, it improves the firm's *absorptive capacity*. (COHEN; LUNDVALL, 1990) Learning is cumulative, collective and depends fundamentally on *codified* or *tacit* organizational routines.

Codified knowledge is interpreted as a form of information, that is, that has a transmission setting, manipulation, and storage and knowledge reproduction. On the other hand, tacit knowledge are personal or group abilities and experiences of subjective character. Although codified knowledge is objective and easily transmitted, tacit knowledge is hardly objective and hardly modified as information. Consequently, tacit knowledge is extremely relevant in the capability development of firms, which differentiate them, once it is subjective and of non-transmissible character. (TIGRE, 2006)

Learning is also an internal and external process to the firm, of cumulative character, and many times path dependent, once advanced information absorption requires previous capacitation related to it. Aghion & Howitt (1998), Tigre (2006) and Arocena & Sutz (2010) different learning processes can bring improvements to a firm's productivity and emerge through experiences, such as: *learning by doing*, related to the production process, *learning by using*, related to the inputs used in production, *learning by studying*, related to the possibility of a person to continue acquiring knowledge, *learning by solving*, related to participation in knowledge demanding activities, *learning by searching*, related to the search process, *learning by interacting*, related to the relationships to a firm's external environment, *learning from interindustry spillovers*, related to industrial externalities and *learning by advances in science and technology*, related to advances on the science basis. These categories are listed in the Table 1:

Table 1. Learning processes and its characteristics.

LEARNING PROCESSES	CHARACTERISTICS
Learning by doing	Learning process internal to the firm, related to new forms of executing processes in the production process.
Learning by using	Related to the use of inputs, equipment and software. It takes place though the utilization of products and promotes conditions to continuous change.
Learning by studying	Related to the way that makes it possible for a person to continue acquiring knowledge throughout their life.

Learning by searching	Based on information seeking and R&D activities.
Learning by interacting	Internal and external, related to networking with suppliers and customers in the production chain.
Learning by solving	Related to the participation in knowledge demanding activities that include problem solving.
Learning from interindustry spill-overs	External, happens through imitation and hiring experienced technicians from the competitor firm.
Learning by advances in science and technology	External, related to the absorption capacity of new emerging knowledge from the international system of Science and Technology (S&T).

Source: Tigre (2006), Aghion & Howitt (1998) and Arocena & Sutz (2010). Own elaboration.

> "The more a firm uses a technology, the better it gets with that technology. Moreover, some of the learning *spillovers* to benefit other firms using that particular technology. Thus, the more a technology is used, the better it becomes *vis-à-vis* its competitors." (DOSI; NELSON, 1994, p. 166)

The learning process seeks the development of production, organizational and technological capabilities. The first two mentioned capabilities refer to the utilized resources in production with a determined efficiency level. Technological capability refers to technical capabilities, individual and collective knowledge and tacit experience.

Learning processes, furthermore, improve a company's absorption capability. (COHEN; LUNDVALL, 1990) Nonetheless, as Teixeira et al. (2016) argues, a firm's capability of acquiring new external knowledge is not exclusively related to the existence of internal R&D activity. It is related to the firm's group of researchers, working as *gatekeepers*, identifying external knowledge independently of an internal R&D structure. A firm's assimilation capability is related to the existence of a group of researchers – *gatekeepers* – as well as to an internal R&D structure.

Teixeira et al. (2016) argues that absorptive capacity is the firm's main dynamic capability that will give her competitive advantages, especially in the most dynamic markets. It is a different learning process than *learning-by-doing*. Absorption capacity allows a firm to benefit from identifying external knowledge – that is, *learning-by-searching* –, allows the firm to keep up with the *technological frontier* and creates a basis to absorb external knowledge, especially scientific knowledge originated in universities. Absorption capacity is a set of previous knowledge a firm has. At the same time, it has a cumulative character, or else, *path-dependent* and is intangible, that is, not codified information: tacit knowledge.

2.3.6 Sources of Innovation

There are two important knowledge sources for innovating. First, there are internal sources, which refer to activities oriented to the development products and processes as well as for incremental improvements, for example, quality-improvement programs, training human resources and organizational learning. (TIGRE, 2006)

The second important source of innovation is external sources, such as:

1. Acquisition of codified information;
2. Specialized consulting;
3. Obtaining licensing for producing;
4. Technology integrated in machines and equipment;

These sources are:

Table 2. Sources of innovation and its characteristics.

Sources of Innovation	Characteristics
Internal technological development	R&D, reverse engineering and experimenting
Contracts of technological transfer	Licensing, patents, contracts for cooperating with universities and research institutes
Incorporated technologies	In machines, equipment and software
Codified knowledge	Books, manuals, magazines, journals, internet, training capacitation, among others.
Tacit knowledge	Consulting, hiring human resources, information about customers, internships and specific trainings
Cumulative knowledge	*Learning by doing, using, interacting* properly documented and diffused in the firm

Fonte: Tigre (2006), own elaboration.

A significant challenge to an entrepreneur is protecting his knowledge from ~~its~~ competitors and potential imitation practices, in order to not experience declining entrepreneurial profits, a privilege from the risk of being a pioneer in the innovative process. Therefore, there are aspects that must be taken care of regarding the appropriability and imitation of the potential innovative process. It aims to guarantee the accumulated economic benefits with convenient appropriability rules, protecting the technological knowledge and technical properties from imitators and other competitors. (CÁRIO; PEREIRA, 2001)

Appropriability condition differs a lot among industries and sectors, which result in high or low levels of appropriability of innovation. There aspects also mean the level in which technology can be transferred between the most different R&I actors. Appropriability is low when knowledge is easily diffused and there is easy access to existing technology. On the other hand, high appropriability refers to the use of protection mechanisms by a firm that owns technology, knowledge, etc., so that this firm can maintain its leading positions and profits, avoiding imitation.

2.3.7 Technology transfer

Regarding technology transfer, there are many channels through which information, techniques and knowledge can flow. According to Tigre (2006), they involve:

i. Contracts regarding technical assistance;
ii. Obtaining licenses for producing a product and commercializing it and licenses for trademarks;
iii. Acquisition of technical services as well as engineering services;

Tigre (2006) argues that commercializing technology through licensing has much more of an international than national character, once firms that own technology try to avoid promoting new competitors in their own markets. While technical and engineering services are not necessarily classified within national and international perspectives. However, there must be special attention on the sector and the consequent improvements in competitiveness, considering there are any. The main forms of technology transfer are listed in the table 3:

Table 3. Forms of technology transfer, mechanisms for technology absorption and requisites for articulating technological and entrepreneurial strategies.

Forms of technology transfer.	Mechanisms for technology absorption.	Requisites for articulating technological and entrepreneurial strategies.
Acquisition of patents or licenses	- Efforts directed to obtaining technology through exchange and cooperation.	- Improving the compatibility between technological and entrepreneurial strategies; - Planning.
Fusion operations, acquisitions or *join-venture*	- Sharing activities among firms with different or complementing capabilities.	- Restructuring a firm, in order to adapt to a new situation and to absorb, easier, new and different information and knowledge.
Acquisition of machines, equipment and components	- Improvement processes, management and products or services; - Networking with suppliers; - Capacitating human resources.	- Optimizing internal processes; - Reorganizing the layout.

Reserve engineering	- Capacitating human resources; - Networking with suppliers and consumers; - Improvements in the productive process.	- Reorganizing the development activities oriented to the scheming and adapting of information to be potentially acquired.
Collecting and analyzing information of catalogs, services or events (fairs, congresses, courses)	- Capacitating human resources; - Networking with information sources;	- Restructuring the data base; - Strengthening internal information systems as well as external information systems.
Hiring technicians working for the competitors	- Acquisition of new human resources.	- Human resources policy.

Fonte: (ALVIM *apud* SIMONINI, 2010)

In order to achieve technological progress in a firm, acquiring new processes (or rights) and taking part of the technological transfer is not enough. Thereafter, acquisition of technology requires many precautions, otherwise there is only a static productivity gain. In order to assure continuous productivity gains and a cumulative evolution, the firm must incorporate their own effort to the process. In other words, Tigre (2006) argues that purchasing a more advanced technology allows for technological improvements to be made to the process or to the product. Nevertheless, when a firm lacks of internal efforts necessary to absorb and to improve a technology (i.e. enhance productivity and develop demands-driven products) and to improve the acquired technology, the firm benefits only from static efficiency gains, once no subsequent improvements on productivity will take place.

2.4 National Innovation System

The National Innovation System (NSI) approach results from non-linear innovation approaches (DAGNINO, 2003; OECD, 1997), typical of evolutionary economics (LEYDESDORFF, 2005) and focuses on socially constructed socioeconomic dynamics influencing innovative processes in a complex system. First, this section will focus on the national character of innovation systems, to then, thereafter, deal thoroughly with the international character of innovative processes.

The definition of national innovation system, however, is non consensual among the different authors and there is no unique definition universally accepted in evolutionary economics. For Freeman & Soete (2000), innovation systems are the interaction between many institutions in the science and technology area, dealing with high levels of education, innovation and technological diffusion. It is an institutional setting, in which institutions are understood as enterprises, educational and research institutions, financing institution as well as the government. In this context, innovation systems consist of heterogenic actors, very distinct between themselves, whose influence in the internal organization of enterprises is not to be underestimated. An innovation system also consist of the relation of actors to other institutions, consists of the role of public institutions and their policy formulation, of the organization of the financial sector and of the structure of R&D programs.

On the other hand, Johnson, Edquist & Lundavall (2003) innovation systems are understood in a broader sense, which is the result of a broader understanding of innovation as a concept. They define innovation system as a "*continuous cumulative process involving not only radical and incremental innovation but also the diffusion, absorption and use of innovation*", and add to it, "*innovation is seen as reflecting, besides science and R&D, interactive learning taking place in connection with ongoing activities in procurement, production and sales*." (JOHNSON; EDQUIST; LUNDVALL, 2003, p. 4)

For Nelson (1993), a national innovation system, besides aggregating the national aspect to it, is defined as a "*set of institutions whose interactions determine the innovative performance of national firms*". However, the OECD's definition focuses on a general view that there are no universally accepted definitions of the concept, but contribute to extend it:

> "The concept of national innovation systems rests on the premise that understanding the linkages among the actors involved in innovation is key to improving technology performance. Innovation and technical progress are the result of a complex set of relationships among actors producing, distributing, and applying various kinds of knowledge. The innovative performance of a country depends to a large extent on how these actors relate to each other as elements of a collective system of knowledge creation and use as well as the technologies they use. These actors are primarily private enterprises, universities and public research institutes and the people within them. The linkages can take form of joint research, personnel exchanges, cross-patenting, purchase of equipment and a variety of other channels. There is no single accepted definition of a national system of innovation. What is important is the web of interaction or the system." (OCDE, 1997, p. 9)

The different understandings on innovation system allow the concept to be analyzed under many different aspects: geographical and sectorial, or according to the extension to which the innovation systems comprehend. (JOHNSON; EDQUIST; LUNDVALL, 2003)

Innovation systems can be geographically classified for being local, regional, national and supranational innovation systems. This association assumes the area in question presents a certain homogeneity in relation to the structure of its innovation system.

The NSI approach presents two significant contrapositions in its analysis to the neoclassical approach. First, critique is the role innovation plays promoting economic development, instead of only improving efficient resource allocation. According to Lundvall (1997, p. 2), "when focused on economic development, successful innovations are more important than efficient allocation". Second, it is assumed that different skills and competences are unequally distributed among individuals, as well as in different regions, nations and firms. There lies the importance of learning processes, taking into consideration that in the learning processes lie the roots of innovation processes. This approach consists of a broader specter in relation to neoclassical innovation economics, as exposed by Lundvall:

> "Especially, this approach takes as its starting point the fact that important parts of the knowledge base are tacit and emanate from routine-based learning-by-doing, -using and –interacting and not only from search activities related to science and technology. This is why we have argued that the prevailing economic structure and the institutional set-up are the core of the National System of Innovation analysis. The policy implications are also more far reaching. Typically, they will relate not only to science/technology and industrial policy but also policy of human resource development and to the institutional set up of markets for labor and finance. Even the ethical foundations of society are important from this perspective – including how society takes care of the losers in the process of change – and it evokes considerations about income distribution and social policies." (LUNDVALL, 1997, p. 11)

With the rise of knowledge-based economy, national innovation systems become relevant, as long as knowledge is a fundamental element of economic development and universities assume an important role in capitalizing knowledge, in improving learning processes and organizing technological transfer to existing firms. On the growing importance of the concept of knowledge production, Etzkowitz (2013, p. 3) argues:

> "Knowledge producing institutions have become more important to innovation as knowledge becomes a more significant element in new product development and in creating the organizational infrastructure for future product development. This expansion of the concept of innovation, in part, explains why university and government have become more significant actors in the innovation process. University, industry and government play this new role in innovation collaboratively as well as individually."

The knowledge base is strictly connected to the sources of obtaining new knowledge, search, routine and selection processes. It is, therefore, dependent on its continuous transformation, instead of being crystallized in static settings. The knowledge base conditions the networking with universities, research institutes, firms and the government and fosters a continuous transformation process of firms, based on technological progress, often originated at universities, it becomes the essence of innovation strategy. (ETZKOWITZ, 2013, p. 22)

Departing from Lundvall's approach on NISs – focusing on the central importance of NSI on defining policy making for economic development – diagnoses the importance of developing policies to encourage development and the technological capability of firms and national organizations, in order to improve national socioeconomic dynamics. The NSI is responsible for guaranteeing the interdependence between basic and applied science, between research institutes and firms that finally bring benefits such as: a) innovation, diffusion and embodying new technologies and; b) the capacity of qualified labor force.

The NSI also has the capacity of defining a technological trajectory. In other words, as a technological trajectory is the synthesis of many coordinated movements among the many available technologies, a well-structured NSI is capable of changing a trajectory and of defining the direction innovations go to.

An important aspect of NSI in generating and diffusing innovations is the interaction between the many actors that compose the innovation system. It constitutes many elements and relations that interact during the production, during the diffusion and that also relate with new knowledge relevant to new market needs. (LUNDVALL *apud* SIMONINI, 2010) Furthermore, the interactions University-Enterprise (U-E) involve all areas in the economy and its elements affect learning processes, which include sub aspects of production, marketing and financing.

The U-E relations, according to Simonini (2010), consist of elements that condition it, among which:

i. The internal organization of firms;
ii. Networking among firms;
iii. The structure of the financial system;
iv. The public sector;
v. The structure of the educational system and R&D organization;

The internal organization of firms refer to, for example, flow of working force, internal policies of promoting human resources, the interaction between production and R&D, etc. The networking among firms refers to the relations between the producer, costumers, suppliers and the interfirm interaction in industrial districts. The structure of the financial system has its impacts on the NSI as long as it determines the amount of credit as well as the innovation trajectory. The public sector has its regulatory power and or orienting the interaction in the innovation system. Finally, the structure of the educational system and R&D organizations influences directly the main input in the production process, knowledge.

However, there are some aspects to be mentioned that negatively affect the harmony in the innovation system. First, the diverging interests between the scientific activities (universities) and the productive activities (firms). Second, the imbalance in public and private resources. While at universities, the focus lies on basic research, firms are more interested in the economic application of the generated knowledge, in other words, if the potential knowledge can be embodied in a commercial good. Besides, there are strong divergences regarding the timing of innovation processes. This concerns the researchers' interests of research independence, while time plays an important role in decision-making when efficiently investing financial resources, firms want results as fast as possible.

In order to affront these difficulties, there are two different approaches discussing the role of the State in optimizing the interaction in an innovation system. One argues against any intervention of the State, while another approach is for State intervention. For those who argue for State intervention, the State can play an important role in a) minimizing factors that influence negatively innovative investment; b) should solve problems that hinders research; c) should identify potential partners and facilitate negotiations; d) should also provide financial funds for project development and; e) take part actively as a third actor interacting in the innovation systems sharing costs and risks, in order to stimulate private investment.

According to this approach, economic development can be fostered by the articulation of a triple setting of actors in the ST&I area, articulating the government, the productive structure and the scientific and technologic infrastructure. Based on a U-E relation and with the government as a third actor in the system, authors such as Etzkowitz (2013) developed a model of a triple interaction, called triple helix model, consisting on the confluence of long term interests of universities, firms and governmental institutions, capable of generating a hyper-cycle. (LEYDESDORFF, 2012; ETZKOWITZ, 2013)

Finally, taking part in a dynamic structured innovation system leads to advantages, such as, according to Ruiz Diaz (2013), universities can benefit from the increase in financial resources, from which can lead to improvements in research infrastructures, as well as improving the human resources capability and improving its absorption capability for further basic and applied research. Regarding the firms, they can benefit from innovation sharing risks and financial means with the university and governmental institutions, acquiring highly qualified working force and improving its human resources through interaction, benefiting from gains in learning processes. Furthermore, firms and universities have access to laboratories and to qualified human resources through other institutions they interact with, which allows both parties to benefit from permanent technological updating. For the government, besides the results on social, economic and strategic technological development, it also benefits from taking part in more complex innovation systems that requires lower investment costs, due to a better infrastructure and installed capacity of R&D.

Investing in technological capability and innovation is essential to the competitiveness of national enterprises and consequently of their success in the domestic and international markets. (SCHUMPETER, 1982) All participants benefit from advantages obtained through their interaction. Universities direct research to determined areas, update the offered subjects, update the course and synchronize it to the last updates in science and the market. In addition, through this interaction, firms are provided with an instrument for permanently updating the available knowledge, and only then, maintain their capability in launching new innovations in the market, as well as of having access to highly qualified personnel, having access to the use of installed infrastructure and technological services. (SEGATTO; SBRAGIA *apud* SIMONINI, 2010)

2.5 Internationalization of R&D

The configuration of global societies has changed drastically in the last four decades. Globalization, higher mobility of factors (production, capital and financing for example), higher mobility of people, and advances in means of transportation (remaking distances) and communication (connecting the most distant parts of the world) has changed the dynamic of social relations and partially the structure of the capitalist system. Meanwhile, the production process of firms has also changed and followed the globalization trend to the degree that firms have internationalized their production, their finances and their cooperation partners – i.e. clients, suppliers, and networking in general – to a higher degree to what was once called multinational enterprises to what now is known as global corporations. (CARLSSON, 2006; RUIZ, 2015; ZUCOLOTO; CASSIOLATO, 2013)

Along with dispersion and specialization of production in the international markets – *global production chains* –, it was observed that Research and Development activities, in some degree, follow production and the production chain. (RUIZ, 2015, p. 418) Many academics have dealt with the theme of internationalization of R&D, its characteristics, its motivations and risks, to its positive and negative effects to the home country, its learning processes and consequences. (RUIZ, 2015; CARLSSON, 2006; CRISCUOLO, 2009; OECD, 2008; KARLSSON, 2006; RAHKO, 2014; ZUCOLOTO; CASSIOLATO, 2013)

The rising transnational flows of R&D shaped a new geography, which up until then was composed hegemonically by countries of the USA-Europe-Japan triad. Now, countries from the South, such as China, India, Brazil, Israel, Saudi Arabia, etc., have began to be net receivers of transnational R&D flows. (OECD, 2008; RUIZ, 2015; ZUCOLOTO; CASSIOLATO; 2013)

Regarding this broader context, this section is going to deal with the internationalization of R&D under the following division:

2.5.1 Characteristics of international R&D

In the evolutionary literature, the most varied taxonomies on innovative activities can be found. Innovations are classified according to their origin and reach: *local-for-local*, *local-for-global*, *center-for-global*, *global-for-global*. (UJJUAL, 2012) On the other hand, according to the technology flow: global exploitation of technology, global technological collaboration and global generation of technology, as aspects of techno globalism. Furthermore, concerning location and knowledge and technology flow: *home-based-exploiting*; *home-country-base*; *host-country-base*; *home-base-augmenting* and; *home-base-replacing*. (RUIZ, 2015) Other authors classify international R&D according to its physical and administrative structure. (BARTLETT, GHOSHAL, 1997 *apud* UJJUAL, 2012, p. 11; ARCHIBUGI; MICHIE, 1995 *apud* UJJUAL, 2012, p. 11; RUIZ, 2015; BNDES, 2012; BNDES, 2013; KARLSSON, 2006) In this section, it is intended to expose the different categories that characterize international R&D.

Concerning the first above-mentioned criteria, internationalization of R&D is categorized by its purpose and characteristics. According to this criterion, international R&D activities can be classified differently, depending on its geographical distribution[1] and depending on the reach of the innovation, depending on consequences of the interaction in the R&I process between the actors involved and how they are geographically spread. Barlett and Ghoshal (1997) *apud* Ujjual (2012) distinct these categories as it follows:

i. *Local-for-local*, when R&I actors and R&I processes deal with the innovation process from the beginning to the end exclusively at a national level and its result also is used only at the national level;
ii. *Local-for-global* are R&I activities, whose actors act at a national level, but the innovations are applied in some locations;

[1] "Past studies have noted the strong influence of national innovation systems on the MNE's technological and innovation activities, highlighting that depending on the sector and home country of the MNE, R&D strategies differed" (UJJUAL, 2012, p. 12)

iii. *Center-for-global*, in the sense that an innovation is created in a central R&D center and has a global reach;
iv. *Global-for-global*, when innovations are result of the interaction and pooling of different resources and capabilities of many different R&I actors and the innovation help solve a worldwide problem;

Moreover, internationalization of corporate R&D presents different forms and characteristics in which it manifests itself. Karlsson (2006, p. 63-64) classifies them in five different forms, which are going to be fundamental for further analysis, studying the characteristics of R&D cooperation between Brazil and the European Union:

i. Multinational R&D activities at subsidiaries located abroad;
ii. Companies accessing knowledge and technologies produced or located abroad through international trade (patent, licensing, inventions, know-how, technical assistance, and R&D services);
iii. Companies cooperating internationally through R&D networks, agreements and alliances between national and multinational companies, between companies and government, universities and research institutes;
iv. Companies recruiting foreign workers for employment in the home country or at foreign R&D facilities;
v. Transfer of knowledge associated with foreign manufacturing of innovative products, trade in high-tech products and diffusion of technologies by reverse engineering;

From another perspective, it is also important to mention that the location of R&D centers of multinational enterprises in their subsidiaries created a new classification of these units. This classification is based on their innovation activities according to their innovation capability or imitation routines regarding its results. Hall (1999) *apud* BNDES (2012, p. 12-13) define international R&D in four unit characteristics:

a. *Local technology unit*, that develop products for the domestic market, based on local technologies;
b. *Technology transfer unit*, that assures an effective technology transfer from the headquarters to the subsidiaries as well as offers technical assistance;
c. *Regional technology unit*, responsible to develop products for regional clients, who share the characteristic and necessities of specific products;

d. *Global technology unit*, that develops products and processes for the most important global markets.

R&I activities tend to internationalize, as previously mentioned, also towards emerging countries. Emerging countries have made many improvements in their local structures to attract foreign investment. Ruiz (2015, p. 421) lists improvements such as amplitude and challenges of the domestic markets; the presence of national enterprises with high absorptive capacity; qualified supply of engineers and scientists; creation of R&D agglomerations in specialized technological parks. The next section is dedicated to drivers and risks of R&D internationalization towards developed and developing countries.

2.5.2 Drivers and risks of international R&D

Over the liberalization process of the 1990's, the rising global corporations started a process of transnational flow of R&D worldwide in search of lower innovation costs, of new market opportunities and access to sophisticated technologies. Many are the reasons as to why companies decide to internationalize their R&D centers. On the one hand, some factors influence some country's attractiveness to receive investment, such as a stability of the institutional environment, industrial and commercial policy, policies towards transparency, good quality infrastructure, renowned research institutes and qualified scientists and engineers. (RAHKO, 2014; RUIZ, 2015; ZUCOLOTO; CASSIOLATO, 2013)

The literature on the internationalization of R&D has improved and presented some shifts over the decades. The early researches on the theme argue that the internationalization of R&D processes are directly linked to *new markets seeking objectives*. While, lately, many other approaches focus on a *knowledge seeking perspective*. (RAHKO, 2014)

The first approach is based on allocation efficiency, arguing that enlarging the market can bring to the firm economies of scale, which can represent a decrease in costs, once, access to new markets consequently give the firm the opportunity of selling its home-made technology abroad. The proximity to a new market brings the firm the necessity of opportunity to adapt the existing product according to the customers' needs and according to local legislation, therefore, improving its innovation capability.

The second approach, on the other hand, focuses the central motivation for internationalization of R&D on the knowledge opportunities, named as *knowledge seeking*. For this approach, the most important reason for internationalizing R&D is to have access to new knowledge, to new institutions, universities, research institutes, other companies, infrastructural and human resources. Furthermore, the proximity to another market, as well as to other cooperation partners, intensify the interaction, and thus the learning processes, inherent to the Research and Innovation process, increasing absorption capabilities and innovation capacities of the firm. Therefore, distributing geographically R&D centers contributes to larger knowledge sourcing opportunities, meaning that more internationalized research centers have larger access to knowledge pools and therefore profit from higher potential knowledge spillovers. (RAHKO, 2014)

> "Even then, the problem is not so much the extent of the R&D performed abroad, but the extent to which the domestic economy benefits from it, if at all. Indeed foreign subsidiaries' innovative efforts may increase domestic technological competitiveness if what is absorbed abroad spills over to other home country firms." (CRISCUOLO, 2009, p. 870)

In another taxonomy, but similar thoughts, Ruiz (2015) contraposes the ideas of already exhausted *home-county-base* perspective, i.e. *home-base-exploiting* and *home-base-augmenting*. The above-mentioned categories are consist with concentrating exclusively its R&D investments in the home country, using domestic knowledge and simply supplying technical support to its subsidiaries abroad. Instead, the perspective *home-base-replacing* deals with the expansion of global corporations to exploit low cost highly qualified personnel in countries outside the triad, seeking efficiency. Efforts towards the efficiency of innovation processes in a global scale, *efficiency seeking*, are a third perspective rather than *market seeking* and *knowledge seeking*.

Zucoloto and Cassiolato (2013) divide the drivers of R&D internationalization in four: *market seeking*; *raw material seeking*; *efficiency seeking* and; *seeking strategic assets*. According to the authors, the first two motivations were of common use by the USA and Europe over the post-war period, while the last two motivations enhance the importance of strategic internationalization of R&D regarding the growing competition originated from the globalization process.

Moreover, according to Ruiz (2015), transnational R&D cannot be explained simply by market seeking strategies or by cost reductions with human resources. A *home-country-base* perspective is insufficient to make clear why global corporations invest in transnational R&D. A *host-country-base* approach started to gain terrain, as long as the attractiveness of receptor countries starts to become relevant in the economic analysis. Motivations for transnational R&D analyzed under a *host-country-base* perspective create three new categories: *host-based technology advancer*, *host-based system owner* and *host-based local integrator*. These three categories are part of global corporations' strategies to access specificities of host countries regarding the knowledge base and new competitive advantages. (RUIZ, 2015; ZUCOLOTO; CASSIOLATO, 2013)

The first category, host-based technology advancer, refers to a demand-pull approach, in which R&D is directed to satisfy a strategic local demand, affecting advanced products and its components and represent new market opportunities. The second category, host-based system owner, refers to R&D processes that integrates knowledge from other R&D units, in order to develop market opportunities in host countries, minimizing technological and market uncertainties. The third category, host-based local integrator, which concerns technological internationalization beyond R&D centers, is responsible to integrate knowledge within the transnational corporation.

The OECD, in its report about the internationalization of business R&D, classifies the determinants of R&D in two greater categories: *centrifugal* and *centripetal forces*. Furthermore, the table is subdivided in two others groups, demand-driven and supply-driven factors. Centrifugal forces mean the factors that influence positively internationalization of R&D and attract business to disperse geographically their R&D centers. "These centripetal forces seem to be increasingly counterbalanced by centrifugal forces favoring the geographical decentralization of R&D" (OECD, 2008, p. 18). Both appear in the table 4:

Table 4. Determinants of R&D Internationalization

Centrifugal Forces	Centripetal Forces
Demand-driven factors:	Economies of scale and scope in R&D
• Need for proximity to local customers	

• Need to adapt products to local market	Fear of leakages of their technology
Supply-driven factors:	
• Access to highly skilled scientific personnel	High coordination and control costs
• Proximity to renowned universities and private R&D laboratories	
• Proximity to potential partners (customers and suppliers)	Strong basis in home country comparative strengths and historical data
• Access to low-cost supply of R&D personnel	

Source: OECD, 2008

A further reason as to why firms internationalize their R&D centers is based on the requirements inherent to the legislation in the host country regarding FDI. Many countries require the implementation R&D activities in the host countries along with foreign direct investment, as a policy towards maximizing benefits followed by FDI. (ZUCOLOTO; CASSIOLATO, 2013)

On the other hand, there are some structural factors influencing the drivers and risks for R&D internationalization, depending on a country's policy or historical, cultural or socioeconomic conjunctures. Ujjual (2012) makes some considerations based on studies on the globalization of US firms:

> "…which suggests that the two key strategic drivers for off-shoring innovation projects are the *speed to market* and the *domestic shortage of science and engineering talent*. At the same time the *loss of managerial control* and *employee turnover* are the most important risks associated with such globalization" (UJJUAL, 2012, p. 16)

In the Brazilian case, these perspectives must be complemented, in order to understand the flow of R&D investments into Brazil. FDI with origin in Germany or the USA take place under a home base perspective, once the FDIs are related to areas of specialization in the home country. Or rather, under home-country-base perspective, in which the technology in question is an expertise in the home country and that its flow to a host country happens with the only objective of offering support to subsidiaries abroad to maximize its effort towards adapting internal knowledge to the local demands. Along with this reason, Brazil became a net receiver of transnational R&D because of four more reasons linked to the consistency of its National Innovation System. First, because of the amplitude and challenges of Brazil's domestic market. Second, because of the existence of national enterprises with high technological capabilities. Third, because of the supply of qualified scientists and engineers graduated in high-level public institutions. Finally, because of the emergence of R&D agglomerations in technological parks. (ZUCOLOTO; CASSIOLATO, 2013)

2.5.3 Effects of internationalization of R&D

Related to the phenomenon of R&D internationalization, this present section intends to deal with possible effects positively or negatively influencing – *spillovers* or *crowding out* effects – regarding the technological performance of enterprises in the host country. Contrary to the idea that cooperation is beneficent for all the parts, Zucoloto & Cassiolato (2013), Ruiz (2015) argue that cooperation for international R&D processes does not necessarily benefit all the involved parts, but can also lead to *crowding out* effects in the host country. Arocena & Sutz (2010) go further in arguing that structural differences in learning processes perpetuate an asymmetric structure of international hierarchy between developed and developing countries. This section, thus, intends to explore the different effects of international R&D in host countries.

Spillovers can occur through the simple interaction between domestic firms and subsidiaries, through knowledge exchange, through routines, etc. Zucoloto and Cassiolato (2013) identified three spillover channels: imitation effect; competition effect and; personnel training effect. Imitation and competition effect are conceptually near to each other. While the first deals with learning processes offered by the subsidiary to the domestic firms (depending on absorption capabilities of the domestic firms), the second refers to spillovers domestic firms benefit from through competition between subsidiaries.

> “Moreover, MNEs not only exploit existing stocks of skill in the host country, but also enhance the knowledge and skill base through a spillover effect thus contributing to the host country innovation system, through specialized trainings given to its employees (ZHU; LIU, 2007 *apud* UJJUAL, 2012, p. 16)”

Technology transfer between transnational corporations and domestic firms can be critical for the convergence or divergence of their technological efforts. Ruiz (2015) argues that a fragile National Innovation System, typical of countries that went through a late industrialization process, determine the degree in which transnational corporations are present in emerging economies. First, as the technological effort is low, scientific and technological activities are of low quality as well. Second, the innovation efforts consist basically on the acquisition of incorporated technologies, rather than on the creation of own technologies. Third, there is a low decision capacity of domestic firms regarding the technological trajectory. In this sense, transnational corporations dominate the decision process. Fourth, the domestic structural heterogeneity, typical of developing countries, influence fragilities on the knowledge base, retarding the diffusion of technologies. (RUIZ, 2015, p. 425-6)

Furthermore, Arocena & Sutz (2010) introduce another aspect in innovative processes that create a gap between developed and developing countries regarding their capability: *learning divide*. The gap emerges basically by the unequal access to learning processes, such as learning by studying and learning by solving, between developed and developing countries.

> "Knowledge-rich countries are such because many people have opportunities to learn both by studying and by solving. Such opportunities are distinctively less frequent in other countries: thus a major 'learning divide' emerges." (AROCENA; SUTZ, 2010, p. 572)

Learning by studying refers to processes of acquiring knowledge though the formal process of studying at tertiary level and regards knowledge supply. While the process of acquiring knowledge by systematically using advanced knowledge for solving problems is called learning by solving and regards knowledge demand. (AROCENA; SUTZ, 2010) Both concepts are highly intertwined. However, knowledge supply is less difficult to foster than knowledge demand. Knowledge demand is the main driver of further learning processes and keep its participant constantly challenged in the knowledge frontier, while constantly challenged to solve societal problems. Most developing countries though, specialize in activities, which are of low learning potentials.

> "…weak knowledge market demand is a more structural problem. Such demand is frequently exogenously oriented, widening the mismatch between capabilities already acquired and opportunities to use them. Historical experience and empirical evidence suggest that fostering knowledge demand is both more difficult and more specific than fostering knowledge supply, so it is located at the heart

> of the development problem." (AROCENA; SUTZ, 2010, p. 581)

Some positive effects are also inherent to cooperation processes for R&D internationalization. Transnational corporations can use technological resources outside the corporation limits, characterizing a spillover. The interaction in the cooperation process can cause many other spillovers to the domestic firms and personnel. Subsidiaries can also work with local scientists and engineers, which work with an intense learning process. These above-mentioned drivers happen along with the OECD (2008)'s factors on centrifugal forces, which according to Ruiz (2015) cause the decentralization of R&D, in order to foster the integration with local scientists, resulting in a greater technological specialization and higher absorption capacity in host countries.

However, for these effects to take place, it is mostly necessary that the host country have the absorption capabilities, in order to internalize the advantages of receiving international R&D centers. In order to build absorption capacity, country receiving R&D financial flows must concern for:

a. the supply of high-qualified personnel;
b. strengthen the entailment between national and international actors of the National Innovation System;
c. to offer modern infrastructure and manufacturing plants;
d. elaborate policies and make use of instruments to reduce the risks inherent to technology development and;
e. to foster incentives to small and medium enterprises. (BNDES, 2012, p. 15)

Finally, it is essential for a win-win situation in international cooperation processes for R&D that the developing country presents efforts in establishing a solid Nationals System of Innovation. In order to reach this goal, national policy should aim to build absorption capabilities, reinforcing institutions, creating an environment that enables a high interaction between R&I agents, building infrastructure and enabling the host country to take part of all levels of learning processes, inclusively the most complex ones – therefore, to avoid learning divides. If so, a host country is ready to benefit from the many advantages of cooperating for technological development.

> "Countries can have many advantages in receiving foreign direct investment in research and development areas, the host countries can receive very important positive impacts

of international R&D investments, such as: technology transfer; improvements in the industrial infrastructure; managerial capacitation; competition among researchers; emergence of new companies; deepening of a culture of technology development." (BNDES, 2012, p. 14-15)

3. Strategy Internationalization of Research and Development of Selected Countries

3.1 Introduction

Knowledge-based economies has become relevant in development discourses. The diffusion of technological activities in diverse economic sectors through many regions may express its benefits in creating employment that requires qualified labor force, reduces socioeconomic inequalities, provides a better access to education and contributes to the welfare of a country's population. (MCTI, 2016; BMBF, 2008; BMBF, 2014)

> "In modernen, wissenbasierten Gesellschaften sind innovative wissenschaftliche Erkenntnis und deren technologische Anwendung der Schlüssel für Wohlstand. Öffentliche und insbesondere private Investitionen in F&E sind die wesentliche Grundlage für Erkenntnisgewinn, Produktivitätsfortschritte und wissenschaftliches Wachstum." (BMBF, 2008, p. 9)

In this context, national policy directed to promoting R&D is essential to and has a strategical role in fostering development, directing investment and benefiting specific strategic areas. That is why a national strategy for Science, Technology and Innovation (ST&I) is of extreme importance and is vital to a country's competitiveness internationally. A structured strategy for ST&I is important for building a network of actors and instruments in a coherent and consistent way, aiming to achieve results for improving socioeconomic conditions.

Globalization has revolutionized – and still is revolutionizing – almost all aspects of our modern day society. Consequently, the recent astonishing improvements in technology changed our perceptions of time and space, connected the world in an impressive way and making interactions more intense and dynamic.

On the contrary, globalization challenges governments to deal with societal problems that affect global society beyond national borders, i.e. air and sea pollution, global warming, etc., and calls for a coordinate strategy to tackle global challenges. Therefore, many countries stress the importance of international cooperation in Science, Technology and Innovation. Besides, international cooperation contributes to fighting global challenges, however; on the other hand, it orients a country's insertion in the global value chains and improves absorption capabilities, bringing a country closer to the frontier of scientific and technological knowledge. (BMBF, 2014)

This chapter analyzes the strategy for Science, Technology and Innovation of Europe, Germany, Italy and Spain, aiming to analyze their efforts in internationalizing their national systems of ST&I – in the case of some countries, it is expressed in an elaborated Strategy for the Internationalization of ST&I. The choice to analyze those strategies specifically is based on: international cooperation between Brazil and the European Union, which is the main focus of this research. Additionally, it is prominent to analyze the European Commission's strategy for internationalization of R&D, as well as the Brazilian strategy for ST&I – which comprises the next chapter.

Furthermore, B.BICE (2015, p. 97) points out the "Member States who collaborate most frequently with Brazilian partners are the United Kingdom, Spain, Germany, Italy, France, Netherlands, Belgium and Portugal". As a reference in ST&I activities in the European area, Germany has a strategy for the internationalization of R&D and is an important country in Europe. Besides, two countries in the CORDIS database that have a significant amount of coordinators in projects of R&D cooperation with Brazil are Italy and Spain. These countries have now become relevant in the analysis of internationalizing their R&D activities.

Official documents available for this analysis are the European Commission's strategy for internationalization of European R&D (COM, 2012a; 2012b), the European Commission's Country Strategy Paper Brazil 2007-2013 (COM, 2007), the German strategy for the internationalization of R&D (BMBF, 2008) and the Spanish strategy for Science Technology and Innovation 2013-2020 (MEC, 2013). Even though Spain presents no official strategy for the internationalization of R&D, there is a chapter in the MEC (2013) dedicated to Internationalization and International Leadership, which is very relevant to the analysis. Lastly, another official document used for this analysis is the Italian national program of research 2011-2013 (MIUR, 2011) as well as the Horizon 2020 Italia – HIT 2020. (MIUR, 2013)

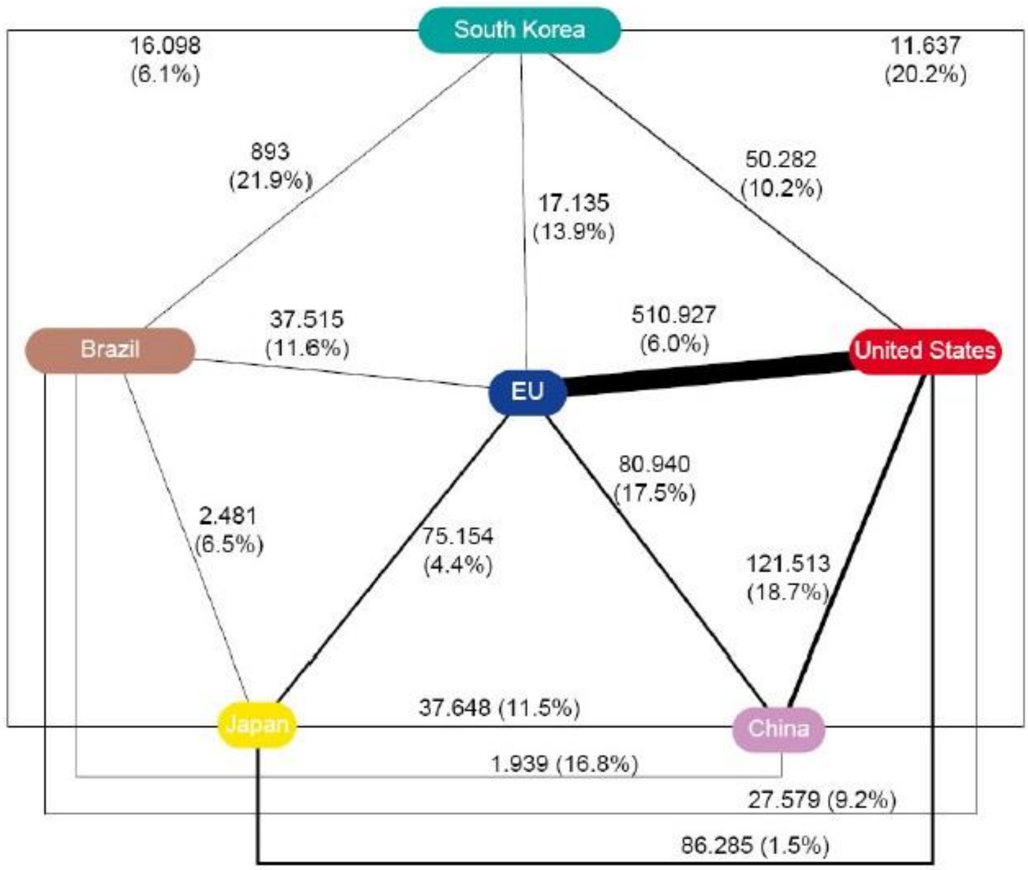
3.2 The European context and the European Commission's strategy for R&D internationalization

The international scenario has drastically changed in the last twenty years. Globalization and the rise of the BRICS countries has shifted the international balance of power in Science & Technology, as the total expenditure of these countries has doubled between 2000 and 2009 (COM, 2012a). Furthermore, the ***relative*** global position of the USA, Europe and Japan has decreased when considering expenditure on R&D (COM, 2012b). The initiative for international cooperation between the EU and Brazil's R&I actors may bring exponentially positive results for their activities. Benefits derived from interaction and learning processes, knowledge flows, as well as from better financial conditions for R&D are fitting examples (COM, 2007). Even though the relative international position of the EU on R&I has been declining, the US-EU-Japan triad are still the main international actors, especially when examining the interaction between the EU and the US in international cooperation. (COM, 2012a; COM, 2012b)

> "The European Union is a world leader in research and innovation, responsible for 24% of world expenditure on research, 32% of high impact publications and 32% of patent applications, while representing only 7% of the population. (…) Over the past decade, however, the landscape has evolved rapidly. Global research and innovation were, until recently, dominated by the European Union, the USA and Japan. As the emerging economies continue to strengthen their research and innovation systems, a multipolar system is developing in which countries such as Brazil, China, India and South-Korea exert increasing influence." (COM, 2012a, p. 2)

This is illustrated by Figure 1:

Figure 1. Scientific co-publications involving the European Union, USA, Japan, South Korea, China and Brazil, 2000-2009.



Source: COM (2012b, p. 5)

Currently, 510,927 scientific co-authored papers are being published between the US and the EU, 37,515 between Brazil and the EU and only 27,579 between Brazil and the US. China, nevertheless, has co-published 121,513 international papers with the US, making it the second most international cooperation that exists with the US. International cooperation between China and Japan has also shown to produce 37,648 co-publications. These projects are equivalent to those that Brazil has shared with the EU.

> "Although Europe, Japan and North America still dominate aggregate STI investment globally, their shares are declining, and the international landscape is increasingly multi-polar. (…) The rapid increase in research and innovation resources outside Europe combined with Europe's relatively weak linkages to emerging research and innovation hubs in Latin America, Asia and Africa (and the Middle East), and the benefits offered by international cooperation in science and technology, underline the urgent need for strategic policy action." (COM, 2012b, p. 9)

The shift in the international scenario, together with the rise of new actors such as China and Brazil, has put these last mentioned countries in the European list of priorities of potential international partners for R&D, who are aiming for excellent research, as "the Union has a clear interest in its neighboring countries developing their research and innovation capacity." (COM, 2012a, p. 2)

The European Commission sees internationalizing its R&I activities as the main strategy to keep and enhance the European relevance in R&I within the international scenario. This has led to the enhancement of a more interactive network between the Member States, a so-called "*Europeanizing*" of the Member States in science and innovation (BMBF, 2014). The goals of the European Commission's strategy for the internationalization of R&D are as follows (COM, 2012a):

a) Strengthening the Union's excellence and attractiveness in research and innovation as well as its economic and industrial competitiveness
b) Tackling global societal challenges
c) Supporting the Union's external policies

Firstly, the European Union wants to create a win-win situation in international cooperation, based on mutual benefit, to stimulate knowledge flow, guaranteeing access to external sources of knowledge. Additionally, by fostering researchers and student's mobility, by attracting investment in R&D, by facilitating access to new emerging markets and reaching a consensus upon common practices for conducting research and exploiting results, the EU would meet is goals.

The measures chosen to achieve this second goal would be through optimizing the use of research infrastructures (COM, 2012a). In Germany's case, transdisciplinary research is essential to effectively fight global challenges (BMBF, 2008).

Coordinating closer trade policies, human and development aid policies that integrate research and development as part of an important pillar in the agenda of foreign policy would achieve the third goal set my the EU. (COM, 2012a)

The European Commission has been implementing many programs to improve ST&I with a series of Framework programs for R&D. For instance, the 7th Framework Program (FP7), valid for the period of 2007 to 2013, is the seventh of a series of FPs and the Horizon 2020 (H2020), valid for the period 2014 until 2020, is the eighth. The

Program Horizon 2020 is a European research-funding program, with a budget of approximately 80 billion euros, that aims to foster R&I programs over the course of seven years (2014-2020), and is complementary to existing structural funds and investments in education. H2020 is part of the European Union's (EU) regional politics, whose goal is to achieve cohesion between the Member's strategies towards R&D policy that could direct the European economy *knowledge driven*, *technology driven* and *society driven*, despite adverse economic conjunctures. (COM, 2012; MIUR 2013)

> "The current economic and budgetary crisis in many European countries are increasingly resulting in a stagnation or even reduction of public spending on research, innovation and education in Europe at the same time as it undermines Europe's ability to attract global talent and corporate STI investments. As a result, the EU as a region risks falling behind. Europe is still attractive as an STI location due to its developed markets, advanced demand and high science and technology capacity but there is increasing global competition for attracting foreign R&D and talent. Overall, the changing global landscape both creates opportunities and increases the need for strengthening internationalization, e.g. due to increasing R&D costs and skills shortages, the emergence of new markets and persistent European and global challenges." (COM, 2012d, p. 9)

The promotion of technological development, through Research & Innovation Policy, R&D activities, aim to foster innovation processes and foster competitiveness in European economies. In fact, the goal of the European Commission is to turn the European Union into an "*Innovation Union*". Absorption capabilities are crucial to a country's competitiveness in *knowledge-based societies*. The R&D potential measures the capacity to innovate and therefore measures the country's capacity to respond with competitive high-value products in adverse scenarios. (COM, 2012b)

The program Horizon 2020 is the succession of the 7th European Framework for Research & Development. Horizon 2020, according to COM (2012b), has its origins in a specific political and economic context and is a response to:

1. the economic crisis – whose origins are in 2008 –, with FP7 and H2020 as an active R&D policy, aiming to promote employment and sustainable economic growth;

2. to central challenges of today’s societies, such as health, energy supply and climate change and;
3. in favor of the empowerment of the EU as a competitive region in the worldwide market, through better Research, Innovation and Technology;

In this context, Horizon 2020 is a result of the unification of three pre-existing programs: the 7th Framework Program for Research and Development (FP7), the Competitiveness and Innovation Framework Program (CIP) and the European Institute of Innovation & Technology (EIT). The focus of Horizon 2020 is to channel its funding resources towards Innovation and Research programs, aimed towards internationalizing the innovation systems of the Member States. The final goal is to make the European Union a worldwide reference for research programs in technologic development. On the other hand, Horizon 2020 also directs resources towards cooperation projects with third countries (an important process when it comes to internationalizing the European research and development programs), in the context of fighting global challenges, even though a great number of resources are directed towards R&D cooperation programs within Europe, among the Member States. The general goal of partnership with third countries is:

> “The main objective of the Agreement [between the EU and third countries] is to encourage, develop and facilitate cooperative activities of the parties in S&T, in areas of common interest, in any form appropriate and structurally feasible, in a manifold of thematic areas, i.e., scientific exchange, collaborative projects, programmes, institutional cooperation up to joint governmental actions in the field of S&T” (COM, 2012c, p. 4).

In order to achieve these goals, the program’s framework aims, through the support of the innovation process in all of its phases: a) for the simplification and complementary character of already existing funds; b) to achieve scientific excellence as well as c) to focus on improving the competitiveness of European industry, in order to promote a leading position of EU companies in the world market (COM, 2012a; COM, 2012b).

> “A strategic approach to internationalization and international cooperation should increase coherence, define actions big enough to make a difference and have clear impacts at EU level and beyond. They should direct EU resources towards initiatives that Member States cannot

> initiate or effectively conduct alone. The European Commission and its resources, such as the Framework Program (FP), occupy a unique position, which should be used to shape cooperation with other parts of the world, using Horizon 2020 as its instrument. The EU should take on a more ambitious global role in STI and become a stronger and more coherent international actor. A clear EU strategy will benefit European Member States, citizens and companies and help the EU to more effectively tackle global challenges." (COM, 2012d, p. 10)

Based on the three goals mentioned above, the European Commission sets the priorities for H2020's budget and the application of these resources. First, approximately 25 billion euros are targeted to strengthen the Union's excellence and attractiveness in research and innovation. They are directed to the European Research Council, who fund scholarships for researcher's formation and mobility and to finance future potential and emerging technologies. Second, 18 billion euros are destined to investments in activities that have shorter effects on innovation, with priority to *Industrial Leadership*, focusing on key technologies. Lastly, approximately 32 billion euros are targeted to projects that tackle global and societal challenges. (COM, 2012a; COM, 2012b; COM, 2012d, MIUR, 2013)

The expected result of the upcoming H2020 is to promote the development of science, industrial competitiveness as well as economic and social development. As the European Commission evaluated, the instruments used at the FP7 were successful, but there are a series of measures, which still need to be improved:

> "The overall evaluation of the instruments used to implement the international cooperation activities under the FP7 Capacities Specific Program is positive. However, it was noticed that the number of current funding modalities is rather high, so could be reduced — as a transition to Horizon 2020 — by consolidating the current instruments in a smaller set." COM (2012, p. 19)

3.3 The German Strategy for Internationalization of Science and Research

> "In addition, the strategies applying to Germany's research and innovation sector are to be adjusted with regard to "Horizon 2020", in order to assure successful German participation in the program." (BMBF, 2014, p. 71)

The internationalization of German R&D aims to give German researchers access to external knowledge, aims to promote interdisciplinary research and to find solutions in cooperation with developed and developing countries, in order to tackle global challenges – as consequences of globalization. Moreover, more than 90% of the world knowledge is produced outside of Germany. The BMBF, therefore, establishes the necessity for Germany to pursue a higher share of global knowledge. (BMBF, 2008; BMBF, 2014)

In this context, the German Department for Science and Research (Bundesministerium für Bildung und Forschung – BMBF), launched a strategy for the internationalization of Science and Research in 2008. This strategy facilitates German scientists and researchers to work together with the best researchers worldwide, to be able to identify new potential knowledge, to cooperate with developing countries and find solutions for global challenges. Consequently, Germany itself remains the European engine and reference in ST&I. Germany sees their strategy for the internationalization of R&D as a "paradigm change in the international dimension of education, research and innovation policy." (BMBF, 2014, p. 23)

The German strategy for internationalization of science, research and innovation should support the goals and missions of German science, research and intermediary organizations internationally (BMBF, 2008). According to BMBF (2014), these goals seek a more mobile, more effective, more efficient, more focused and more competitive ST&I system. Furthermore, it aims to identify the best knowledge and optimal structures internationally, in order to foster Germany's international relevance and reference as an attractive spot for research and innovation. The strategy presents four priorities (BMBF, 2008; BMBF, 2014):

i. to strengthen the cooperation with the world's best researchers and scientists;
ii. to identify international innovation potentials;

iii. to strengthen a sustainable ST&I cooperation with developing countries;
iv. to assume international responsibility and fight global challenges;

In order to achieve these above listed goals, the BMBF (2008) presents six political measures necessary to achieve the international oriented political measures.

a) Foster mobility of German scientists and guarantee them access to research infrastructures in other countries;
b) Coordinate strategically national, international and regional programs, in order to optimize German foreign investments in R&D;
c) Coordinate and complement the instruments of development aid and scientific-technologic cooperation aiming the strategic interests of Germany and its partners;
d) Preparing a Research Agenda to fight global challenges, result of globalization, with an interdisciplinary focus;
e) Promotion of Germany as an international reference for science, research and innovation;
f) Promote the coordination of an European strategy with the German internationalization strategy;

3.3.1 Internationalize science and higher mobility

First, the BMBF identifies a higher mobility for German scientists and their international-oriented promotion and development, as an important aspect for the internationalization of R&D. For instance, the international-oriented formation of German scientists will grant them access to foreign research infrastructure, equipment and access to cooperation projects associated with international researchers (BMBF, 2008). The interactive contact with international actors can intensify learning processes and improve the outcome of innovation projects through access to external knowledge. External knowledge is crucial for the German strategy:

> "Modern mobility policies are vitally important for Germany's industry and science sectors, since more than 90% of all knowledge worldwide is generated outside of Germany. German scientists need to be mobile, and

> Germany needs to be open for foreign scientists." (BMBF, 2014, p. 61)

The strategy focus on facilitating the mobility of German scientist. With the mobility program, German researchers can create international networking, can take part in international cooperation and international financing programs and have the chance to increase German participation in international projects. An example of institutions that work actively for the internationalization of German researchers are: the Max Planck Society, the Helmholtz Association, the Fraunhofer Institute, the Leibniz Association, the German Research Foundation, the German Academic Exchange Service and the Alexander von Humboldt Foundation, among others (BMBF, 2014).

All these above mentioned goals are part of a major aspect to strengthen the attractiveness of German universities and research institutes and to strengthen Germany as an attractive country for foreign investments in R&D. As long as these conditions are achieved, the environment is favorable to create opportunities to keep foreign scientists in Germany as well as to stimulate the return of German scientists living abroad.

Nonetheless, it is expected that a higher international mobility of scientists can cause negative consequences for some countries. A higher international circulation of scientists can cause a *brain drain* phenomenon to countries, where the Innovation System, as well as the infrastructure and excellence is more developed than the original country and provides the scientists better opportunities. In order to avoid undesired scientific emigration in developing countries, a new approach is proposed, ~~for instance,~~ to foster a narrow and long-term cooperation according to the interest of both partner countries. The idea is to stimulate *brain circulation*, rather than creating a *brain drain* in developing countries.

3.3.2 Strategically coordinated financing programs

Second, international financing programs must be strategically coordinated with all actors involved, in order to efficiently complement themselves. These financing programs should foster German investments in foreign locations and must be of highest use for Germany.

3.3.3 Collective participation in the formulation of cooperation programs

Third, the instruments for cooperating with partners for S&T development cooperation projects must be collectively articulated with all partners involved, in order to include all partner's priorities and to foster cooperation partnerships that uphold the interests of all parties.

3.3.4 International and transdisciplinary agenda to fight global challenges

The fourth instrument is to formulate and implement an international research agenda to fight global challenges. In order to deal constructively with the causes and consequences of globalization, the German strategy for ST&I will strengthen the international cooperation with human sciences knowledge areas. Only including human-sciences as a priority in research and dealing with globalization as a transdisciplinary phenomenon will make it possible to identify globalization's causes and consequences on global society.

3.3.5 German presence abroad

The fifth instrument is to promote the presence of German researchers abroad. German organizations are going to inform about strategic trend of economic, scientific and innovation activities abroad and are going to promote Germany as a reference place to do research and innovation internationally. The aim is to make Germany an "innovation reference", e.g. it is the European Union's goal to turn the European Union into an "Innovation Union".

3.3.6 Secure the best outcome for Germany

Sixth, the European as well as a specific country's strategy for the internationalization of R&D will orient itself on the goals of the German strategy. The BMBF will monitor the German internationalization strategy every three to five years, contracting an independent and international staff of experts to evaluate, which goals were reached and goes along with the German interests. (BMBF, 2008)

	2009	2010	2011	2012	2013	Funding growth 2009-2013	Total (2009-2013)
(Direct) project funding	194	222	253	303	344	77,32%	1316
With EU partners	74	86	99	103	109	47,30%	472
With non-EU partners	120	136	154	200	235	95,83%	844
Contributions to international research programs and R&D infrastructures	373	473	432	419	402	7,77%	2099
Total	567	695	685	722	746	31,57%	3415

Table 5. Overview of BMBF project funding for international projects, and BMBF contributions to international research programmes and R&D infrastructures (2009-2013; in millions of euros).

Source: BMBF (2014, p. 11)

BMBF (2014) recognizes bilateral cooperation as an important aspect to complement Horizon 2020.

> "In the BMBF's view, it is also necessary to efficiently coordinate "European" measures and bilateral activities. For the BMBF, bilateral cooperation remains one of the central pillars of the ERA. Such cooperation complements cooperation at the European level, both structurally and substantially. In order to intensify integration of the different levels involved, the BMBF plans to work to intensify inclusion, in EU programmes and activities, of the networks and thematic areas arising via bilateral activities." (BMBF, 2014, p. 71)

In fact, table 5 depicts the amount of projects funded by the Federal Ministry of Education and Research (BMBF) from 2009 to 2013. In the period, the BMBF provided 3,4 billion euros for international cooperation in R&D. First, it is important to stress the significant evolution of project funding during that particular period. In five years, the direct funding grew 77,32%, from 194 million to 344 million euros. Among the projects with direct funding from the BMBF, 64,13% are projects in cooperation with non-EU partners, while only 35,86% of the direct funding goes to projects with EU partners. While non-EU partners are more relevant partners for Germany, the cooperation with non-EU partners presents a higher evolution (95,83% growth), double the pace than the evolution of cooperation projects with EU partners (47,3% growth). It is also important to emphasize that the 2 billion euros spent in the period on international research programs and R&D infrastructure, represents 61,46% of all funding during this period.

Regarding the focus of this research, Germany identifies the BRICS as strategic partners for S&T cooperation, especially Brazil. Even though Brazil is not one of the greatest German partners in S&T, Brazil represents the largest partner for German industries.

> “Brazil is the largest business location for Germany companies abroad. In recent years, Brazil has successfully expanded its scientific production, and in less than a decade it has doubled the size of its scientific training sector.” (BMBF, 2014, p. 51)

3.3 The Spanish strategy for internationalization of Research & Development

The Spanish strategy for Science, Technology and Innovation deals with a context still strongly influenced by the 2008’s economic crisis. The scenario had changed in 2010 when R&D financing, after years of increasing numbers, started to decline – in both private and public financing. The Spanish Department for Economy and Competitiveness (MEC) aims to improve the absorption capabilities of the Spanish System of Science, Technology and Innovation, that is, facilitating the cooperation between all parties involved is to “increment social and economic growing returns, result of investment in R&D” (MEC, 2013).

Since 2008, the global economic crisis unbalanced Spain’s economy, with low investment rates that affected Spanish competitiveness and unemployment rates. However, the government recognizes “education, improving the country’s capability to generate scientific, technological knowledge, innovation and the necessity to entrepreneurial investments in R&D as the engines that promote change and growth in the context of a growing transformation of international competitiveness.” (MEC, 2013)

Furthermore, regarding international trends, the Spanish Department for Economy and Competitiveness recognizes globalization as a phenomenon that reshaped the global setting of knowledge, technology and innovation, as these factors are determinant to promote international leadership of universities, public institutions, firms and research institutes in a highly competitive international scenario. Herein lies the importance of a national R&D strategy, as well as a strategy for internationalizing R&D: the absorption of capabilities to enhance the industry's competitiveness and promote sustainable economic growth, in order to tackle challenges caused by globalization, which goes along with the European Commission's strategy for the internationalization of R&D (MEC, 2013):

> "The global picture in research and innovation is rapidly shifting. Emerging powers in science, technology and innovation, in particular the BRIC countries (Brazil, Russia, India, China), are challenging the USA, the Union and Japan. In this context, the Union's relative position on the global scene has remained remarkably stable over the last decade, except in R&D expenditure and PCT patents (…) The evolution in the world share of PCT patent applications shares shows that both the Union and the USA are losing ground to the dynamic Asian economies. In general terms, the decline is more pronounced for the USA and Japan than for the Union." (COM, 2012b, p. 2-3)

This argument is strengthened by:

> "El escenario en el que se desarrolla el conocimiento científico y técnico y se suceden las innovaciones es muy dinámico; una característica que ha provocado que los países que tradicionalmente habían ostentado una indiscutible posición de liderazgo científico y tecnológico se enfrenten ahora al desafío asociado al creciente peso en materia de I+D+i de terceros países, más aún entre los países BRIC -Brasil, Rusia, India y China."[2] (MEC, 2013, p. 35)

In the above mentioned lines, the MEC confirms the analysis of the COM (2012a; 2012b; 2014) about the relative decrease of participation in global expenditure on R&D, in face of the growing importance of emerging countries, as the BRICS. One the one

[2] "The scenario in which scientific, technical knowledge and innovations develop is very dynamic; a characteristic that allowed countries that traditionally held an undoubtedly scientific and technological leadership position is collapsing, as the rise of emerging countries challenge the hegemonic power, balancing the world based on the increasing amounts of investment in Research, Development and Innovation, especially among the BRIC – Brazil, Russia, India and China." (MEC, 2013, p. 35, own translation)

hand, MEC (2013) intend to solidify the Spanish National System of Innovation and enhancing the competitiveness of national industry. On the other hand, to enhance internationally the European Member State's position and by enhancing the European status as global reference in ST&I.

In the Spanish case, the guidelines for the internationalization of R&D are entangled in the National Strategy for ST&I as a brief chapter. It reflects the recent introduction of effort towards building a National System of Innovation in the country and explains its low international level. Despite the low openness of the Spanish research internationally, many improvements were achieved and are going to be the guidelines for further improvements towards an international openness of Spanish Science and Innovation (MEC, 2013), such as:

a) an improvement in scientific international cooperation;
b) an increasing participation in international organizations and infrastructure programs, such as the FP7, the CERN, the European Space Agency, ITER, EMBL, among others;
c) an increasing participation of private firms in bilateral and multilateral programs for technological cooperation;

Another aspect that expresses the efforts of coordinating the Spanish NSI and the European strategy for internationalization of ST&I is, according to Mec (2013), coordinating strategies is highly important for elaborating a successful long run strategy for ST&I. It seeks projecting Spanish and European Science and Innovation internationally, as it is a critical factor for enhancing Spanish and European competitiveness, whose results would reinforce the Spanish System of Science, Technology and Innovation.

> "Por otra parte, la evolución de las políticas de I+D+i de la Unión Europea hace necesario incrementar la coordinación entre la política nacional y la política europea en materia de I+D+i, y promover la participación de investigadores, centros de investigación y empresas en el desarrollo y consolidación en los instrumentos de financiación diseñados para ello, entre los que destaca el nuevo programa marco europeo de I+D+i, «Horizonte 2020», que cubre por primera vez el ciclo completo, desde la

> concepción de la idea hasta su puesta en el mercado[3]." (MEC, 2013, p. 35)

In this context, these efforts aim to develop the Spanish National System of Innovation and aim to contribute enhancing the scientific, industrial, entrepreneurial absorption capabilities in Spain. Based on these before mentioned ideas, the goals of the Spanish National Strategy for Science, Technology and Innovation, regarding its internationalization and international leadership are:

i. Optimize the synergy between the Spanish, European and its Member States R&D efforts, creating an integrated framework for R&D cooperation;
ii. Strengthen the scientific-technological and entrepreneurial cooperation with third countries, especially with Latin America and with the Mediterranean countries, with which there is already a vast history of cooperation and important complementarities;
iii. Support action that help go through with the framework on foreign policy that enhances ST&I relation and cooperation between Spain and third countries and with International Organizations and support actions that sustain a policy towards international cooperation for development;
iv. Improve the attractiveness of Spain's R&D activities internationally, with research based on excellence and cutting-edge research, in order to attract global talents, international scientific and technological infrastructures, international investment in R&D and cooperation with Autonomous Communities;
v. Improve the international presence of Spanish innovative firms and support their presence and participation in commercial networks and global markets;
vi. Reinforce Spain as an image internationally seen as linked with excellence scientific research and as entrepreneurial leadership as key sectors of the Spanish economy;

[3] "On the other hand, the evolution of European R&I policies makes it necessary to coordinate the national with the European policy on R&I and to promote the participation of researchers, research centers and firms in the development and consolidation of the financing instruments designed for such activities, under which, the new European Framework Program for R&D, "Horizon 2020", for the first time involves the whole cycle, from the conception of the idea until its introduction to the market." (MEC, 2013, p. 35, own translation)

vii. Upgrade the visibility of Spanish science abroad, primarily through the creation and consolidation of Spanish Researcher Communities abroad;

Among these seven goals established by MEC (2013) as guidelines for Spanish ST&I policy until 2020, practically all of them go along with the German strategy goals for internationalizing the German NSI and simultaneously shows the synergy between the Spanish and European guidelines towards the internationalization of European R&D.

Mec (2013) argues that, in addition to these seven goals, there must be combined development "measures to encourage Spanish participation in European R&D programs". These measures are, first, to promote talents integrating R&D technicians and managers specialized in European projects. Second, to finance scientific research with excellence status, detecting potential participants who are able to take part in European projects (this means giving support to present proposals, financing approved projects but not those financed by the European Research Council and the creation of a network, supporting the participation in Horizon 2020). Third, it is important to improve entrepreneurial leadership through identifying firms who are able to participate in Horizon 2020. (MEC, 2013)

The Spanish Strategy for R&D Internationalization stresses a further important point. It calls for special attention to be drawn to the need of dedicating R&I actors to research not only on the national level, but also on international projects that present efforts to tackle societal challenges. (MEC, 2013, p. 36)

Finally, the guidelines established for the National Strategy is essential to understand the principles, on which R&D internationalization in Spain is being developed. MEC (2013) presents clear guidelines of a national strategy that coordinates Spanish efforts for Science & Innovation policy with the European strategy and with Horizon 2020 towards achieving the goal of building an "Innovation Union".

3.3 The Italian strategy for internationalization of Research & Development

The Italian strategy is based on the diagnosis that the research and development potential of every country contributes positively to industrial competitiveness, coherent to the concept of *knowledge-based societies*. The R&D potential measures the capacity to innovate and therefore measured the country's capacity to respond properly to the society's needs. Innovation is a dynamic process, extremely interactive and interdependent on the relationship between research, invention, development and production (MIUR, 2013).

Environmental sustainability, it is important to stress, is one of the main guiding principles of the Italian National Research Program (MIUR, 2011; MIUR, 2013). In harmony with the diagnosis of the German and European strategies for R&D internationalization, the globalization process causes global challenges, that trespass national borders and cannot be solved within the National State approach. The focus on natural sciences with an interdisciplinary approach follows the German and European principles and long-run goals to serve as inspiration to the elaboration of the Italian Strategy (MIUR, 2011).

The international aspect of R&D is a complementary aspect in the Italian Strategy for National Research, while the Department of Education, University and Research (MIUR) show efforts that are guided towards consolidating the Italian National Innovation System. Through its consolidation, it can be understood as the improvement of a legal framework to stimulate a higher interaction between firms, universities, research institutes and the government and have its effects on improving public-private partnerships, financing research infrastructures and building capabilities. (MIUR, 2011)

Enhancing the effectiveness of an interactive network is crucial to promote a higher competitiveness of the Italian science and research and improve its international status. Inspired by the *knowledge-based economy,* the Italian National Program for Research (MIUR, 2011) realizes and expresses the important nexus between technological development and socioeconomic development, as follows:

> "Pur senza prefigurare alcuna autarchia, e avendo ben presente la realtà globale dell'economia e della tecnologia, sarebbe miope non considerare la necessità di favorire, dove esistano adeguate condizioni di conoscenze scientifiche e produttive, il massimo di trasferimento di conoscenze e attività. Lo sviluppo del sistema produttivo è la premessa per aumentare i livelli occupazionali e adeguare le Politiche di welfare. Per questo il PNR intende rafforzare il ruolo

> delle Università e degli Enti di Ricerca di sostegno allo sviluppo del Paese [4]" (MIUR, 2011, p. 27).

The National Program for Research sets some principles that should be the guideline for further policies. For instance, increasing the financial means to research (as well as improving its effectiveness and support the condition for the emergence of talents, merit and excellence research). These principles are:

a) improve a central institutional coordination to avoid the divergence between multiple regional administrations;
b) to stress the importance of social, economic and environmental sustainability in science and research;
c) prioritize the formation of human capital, aiming the achievement of excellence research;
d) improve the University-Enterprise relation;
e) the priority of the Program is to stimulate basic and incremental innovation that have a significant economic applicability;
f) support national researchers to submit calls for projects of European projects and promote the international insertion of Italian Research;
g) Efforts must be directed towards promoting an "Innovation Union"
h) Central and regional policies should be harmonically coordinated towards intervention in entrepreneurial research;
i) Policies' instruments must be diversified;
j) Support the internationalization of Italian Research Institutions;
k) The priorities of this document will be updated according to monitoring analysis of a R&D database;
l) Introduction of the best logic and methodology of international programs towards the administrative simplification, following the EU standards, in order to achieve the status of an "Innovation Union";
m) These same priorities will set the guidelines for North-South cooperation for projects of research and research infrastructure;

[4] Before seeming to express any autarchy, and having present the global reality of economy and technology, I would be shortsighted not to consider the necessity to support the most knowledge transfer as possible where there is adequate conditions for scientific and productive knowledge. The development of the productive system is the premise to increase the employment level and to adequate welfare policies. In this scenario the National Program of Research intents to reinforce the role of Universities and Research Institutes, in order to sustain the Country's development". (MIUR, 2011, p. 27, own translation)

The MIUR is going to support the achievements of these goals, aiming to enhance industrial competitiveness, through technological development, and "with harmony to the goals set by the program "Europa 2020", the European Strategy for Economic Growth in the European Union (MIUR, 2011, p. 31).

Especially in Italy, the MIUR elaborated a funding program, called HIT 2020, whose goal is to coordinate the National ST&I policy with Horizon 2020. HIT 2020 is an instrument that guarantees a medium and long-term project, works as a funding mechanism, complementary to the H2020 funding and supports the implementation of policies supporting R&I activities (MIUR, 2013, p. 30-31). The Italian government presents, in fact, a great effort enhancing the coordination between the Italian national system of innovation and Horizon 2020. HIT 2020 describes "an innovation system which is solid and efficient, not fragmented, with a solid network among its actors and strategically oriented to generate economic welfare and social cohesion: this is the great goal of HIT 2020" (MIUR, 2013, p. 26).

The fragmentation of regional R&D policies inside Italy and the different Member States, is seen as a problem by MIUR, and there lies the importance of HIT 2020 coordinating a synchrony among all policy makers:

> "Con HIT 2020 s'intende porre fine all'estrema polverizzazione delle attività di cooperazione internazionale nella ricerca e nell'alta formazione favorendone l'inserimento nella strategia più ampia di supporto alla competitività del sistema Paese. A tal fine si procederà ad una ridefinizione delle attività favorendo una più efficace integrazione tra i diversi enti coinvolti. Questa azione ovviamente punterà anche a costruire o rinforzare l'interoperabilità dei sistemi di ricerca ed alta formazione nel loro complesso, e a inquadrare quelle iniziative che rappresentino lo sbocco internazionale di quei poli territoriali (clusters) che si stanno cominciando ad intravedere e che HIT 2020 contribuirà a sostenere e consolidare[5]" (MIUR, 2013, p. 60).

[5] "With HIT 2020 it is intended that an end is put to the pulverization of international R&D cooperation activities, supporting the implementation of a wider strategy to support the EU's competitiveness, in a country-base. In order to achieve this goal, it is necessary to redefine these activities, in order to support the integration of all actors involved more efficiently. This action concentrate its efforts, obviously, towards improving and reinforcing the inter-operability of research systems and the formation of clusters, whose international activities should be supported, once it has been recently declining and that HIT 2020 is going to contribute and help consolidate" (MIUR, 2013, p. 60, own translation).

The Italian Ministry, MIUR, has a specificity regarding its national strategy for R&D, which is the historical cooperation with the Mediterranean countries. For instance, this historical relation Italy and neighboring countries extend to ST&I cooperation. The MIUR set in its goals the integration of R&D activities in the Mediterranean area, a program called PRIMA. International cooperation's focus is on cooperating on R&D projects with the Mediterranean countries, with which Italy already has a historical partnership.

The last aspect is the importance of researchers' mobility as part of an internationalization strategy of the Italian National Innovation System, in order to achieve excellence research status, solidify an efficient NIS and contribute to technological development and industrial competitiveness. MIUR (2013, p. 60) emphasizes the importance of properly regulating mobility projects and international cooperation with partners, in order to avoid a negative balance concerning researchers mobility (*brain drain*), a problem Italy has faced in the last couple of years.

4. Brazilian Strategy to Internationalize Science, Technology & Innovation

> "The problem is not so much the extent of the R&D performed abroad, but the extent to which the domestic economy benefits from it, if at all. Indeed foreign subsidiaries' innovative efforts may increase domestic technological competitiveness if what is absorbed abroad spills over to other home country firms." (CRISCUOLO, 2009, p. 870)

4.1 Introduction

Brazil has gone through many transformations in many different areas throughout the 21st century. Reduction in extreme poverty, social inclusion and economic growth have increased Brazil's political relevance internationally. Through these changes, the country has been able to overcome many of its structural barriers in development.

In the past few decades, economic development has become increasingly dependent on innovation as well as scientific & technological progress. Many developed countries have understood this phenomenon and directed innovation policies towards ST&I. A strategy for science, technology and innovation has become central to the development debate, which aims to fight the economic crisis and foster long-term sustainable economic growth. R&D policies are often based on strengthening the scientific base, building absorption capabilities and improving networks between R&I agents, through a more solid National Innovation System. These measures tend to strengthen a firm's innovation capability and enhance a country's industrial competitiveness. (MCTI, 2012)

In the case of emerging countries, technological development plays an important role in tackling societal problems, overcoming poverty as well as social and economic inequality. ST&I, "particularly in the case of emerging countries", is essential because "low scale technologies contribute to social inclusion and poverty reduction and that is why they deserve to assume an outstanding position in development policies" (MCTI, 2012, p. 32).

> "A ciência e a tecnologia podem contribuir com soluções criativas para melhorar a qualidade de vida da população, com o desenvolvimento de novas tecnologias urbanas e habitacionais, aderentes às necessidades de construção de

> uma economia verde e sustentável. Nesse sentido, investimentos em tecnologias podem ajudar a equacionar problemas ambientais no meio urbano, tais como o enfrentamento de enchentes e deslizamentos, que afetam mais fortemente a população carente que vive em áreas de risco e em condições de vulnerabilidade social. (...) Outro campo de atuação é no fomento à tecnologias de pequena escala que contribuam para o fortalecimento da agricultura familiar[6].” (MCTI, 2012, p. 39)

The persistent formulation of ST&I policy has contributed to the enhancement of Brazilian capability through “the improvement and empowerment of the research and scientific production and knowledge” (B.BICE, 2015, p. 97). The Brazilian National Strategy for Science, Technology and Innovation (ENCTI) for 2016-2019, stresses the importance of such strategy for promoting justice and social equality policies, based on extensively applying science, besides developing and diffusing locally appropriated technologies. (MCTI, 2016)

4.2 Recent Evolution of the Brazilian Science, Technology and Innovation Structure and Characteristics of the Brazilian National Innovation System.

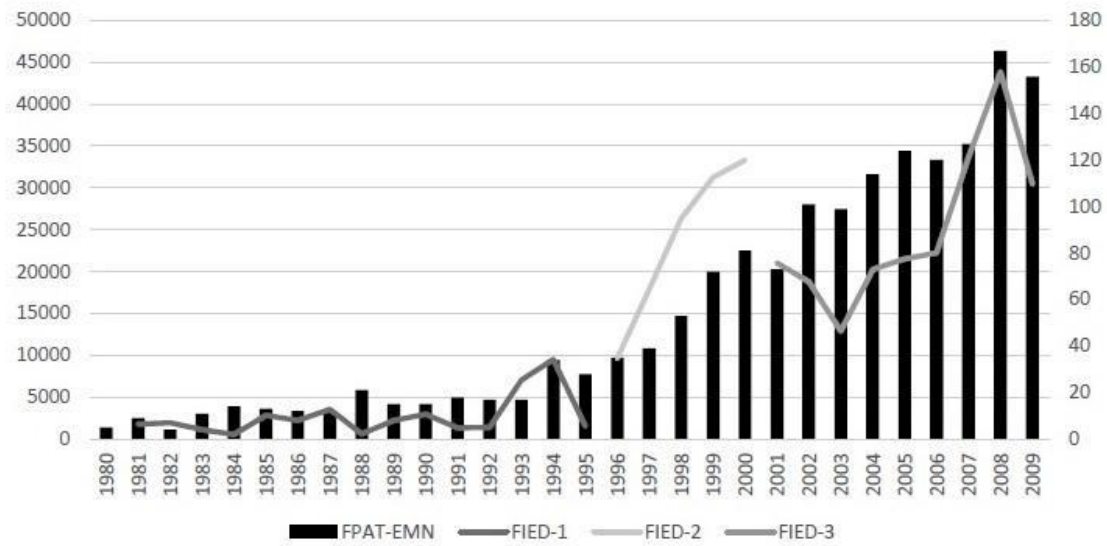
Brazil became a relevant country for R&D in the 2000’s after having presented improvements in many aspects. The country has received an increasing amount of Foreign Direct Investment (FDI), according to Chart 1. In the early 2000’s, the flow of FDI started at a level of US$ 70 billion and by 2009, had reached a high of US$ 160 billion, a rapid increase of 128%. The flow of patents follow the same tendency as the data for FDI. Both indexes represent important criteria in international technological insertion of entrepreneurial activity in Brazil.

> “Nos últimos anos, o Brasil passou a se incorporar no grupo de países emergentes receptores líquidos de influxos transnacionais de P&D, sendo esta uma tendência que acompanha os influxos de investimento estrangeiro direto

[6] “Science and technology can contribute to creative solutions to improve the population’s quality of life, through the development of new urban and housing technologies being directed to the construction of a green and sustainable economy. In this sense, investment in technologies can help tackle environmental problems in urban areas, such as high water and landslides, which directly affect the poorest parts of the population, who live in these high-risk areas and vulnerable conditions. (…) Another area of action is to foster low-scale technologies that contribute to strengthening family agriculture.” (MCTI, 2012, p. 39, own translation)

(IED). Durante os anos 1980 e início dos 1990, os fluxos de IED se mantiveram relativamente estáveis. Mas a partir de meados da década de 1990, os estoques de IED passaram a crescer num ritmo exponencial (Gráfico 1). Uma medida da evolução da inserção tecnológica das GCTs no Brasil é o número de patentes depositadas por GCTs com inventores brasileiros. Este indicador segue praticamente a mesma evolução que a apresentada pelo IED. Ou seja, a entrada de capital estrangeiro no Brasil se encontra altamente correlacionada com a evolução crescente das atividades tecnológicas das grandes corporações no país." (RUIZ, 2015)[7]

Chart 1. Foreign direct investment and patent flows in Brazil, 1980-2009.

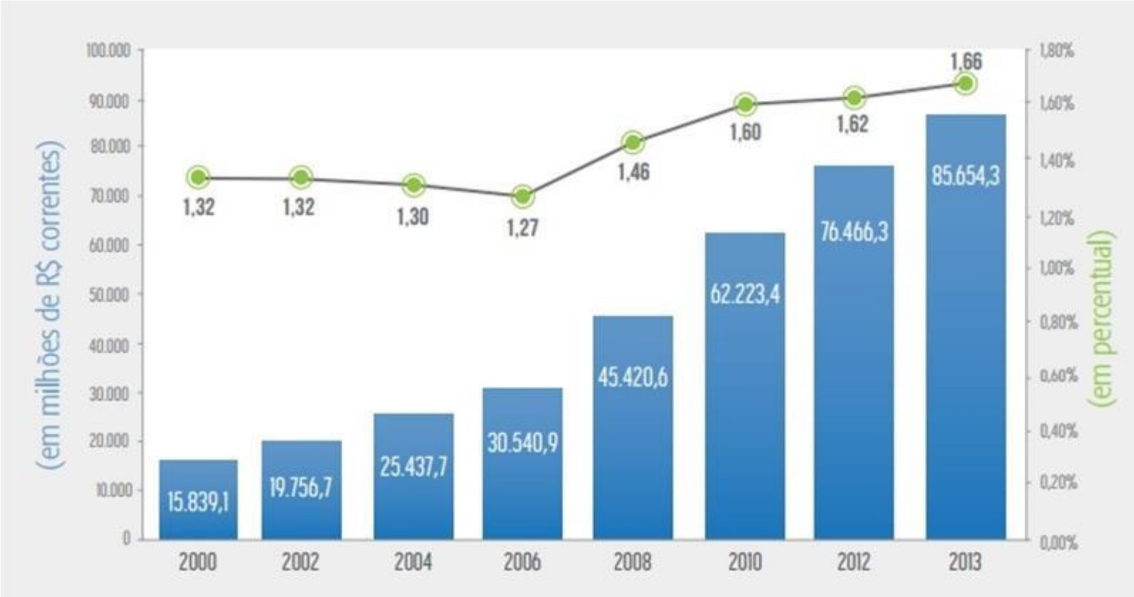


Source: Ruiz, 2015.

Following the same pace and supporting the argument of Ruiz (2015), the total gross expenditures in Science & Technology (S&T) grow rapidly from an amount of R$ 15,839 billion in 2000 to R$ 85,654 billion in 2013. An impressive 440,7% growth rate! The gross expenditures in S&T in relation to GDP grow as well from 1,32% in 2000 to 1,66% in 2013, as illustrated in Chart 2.

[7] Over the last few years, Brazil started to take part in the group of emerging countries, which are net receptors of transnational R&D flows, as a tendency that follows the flow of Foreign Direct Investment (FDI). During the 1980's and early 1990's, FDI flows were relatively stable. However, in the mid-1990's the FDI stocks started to grow at an exponential rate. An important criterion of evolution of international insertion of Transnational Corporations in Brazil is the amount of patents required by Transnational Corporations with Brazilian inventors. This data exactly follows the evolution presented by the FDI flows. This means, the inflow of foreign capital into Brazil presents a positively high correlation with the growing evolution of technological activities of big corporations in the country. (RUIZ, 2015, own translation)

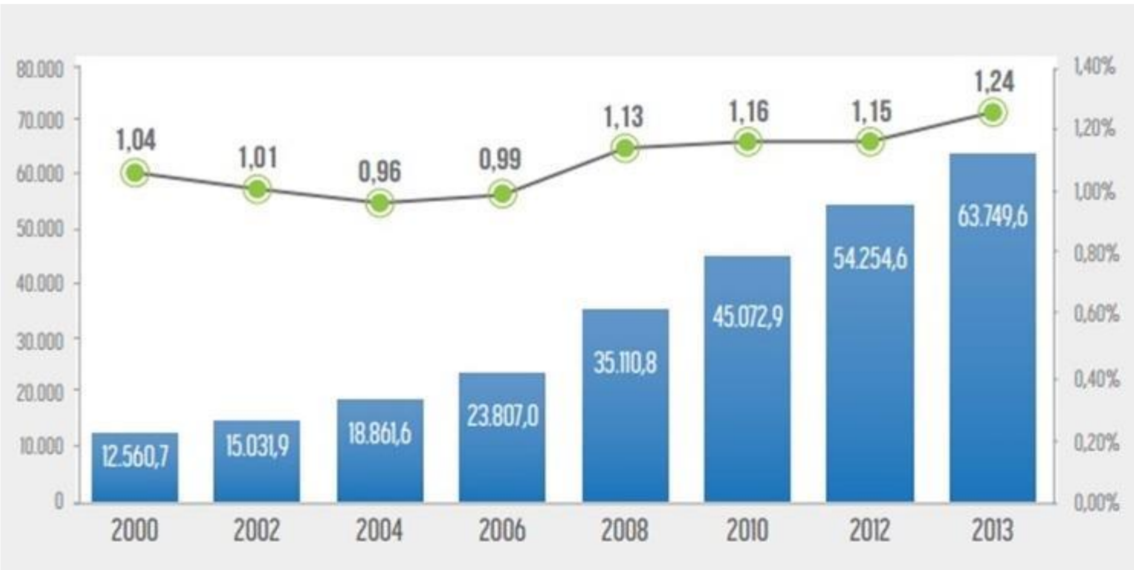
Chart 2. Expenditures on S&T, value of 2013, and expenditures on S&T as percentage of GDP from 2000 until 2013.



Source: MCTI

The same trend is seen when looking at the total gross expenditures on R&D. While total expenditures summed R$ 12,560 billion in 2000, it reached a level of R$ 63,749 billion in 2013, a nominal growth of 507,53% during that period. Total gross expenditure on R&D in 2013 represented 1,24% of GDP, as compared to only 1,04%, back in 2000 according to Chart 3:

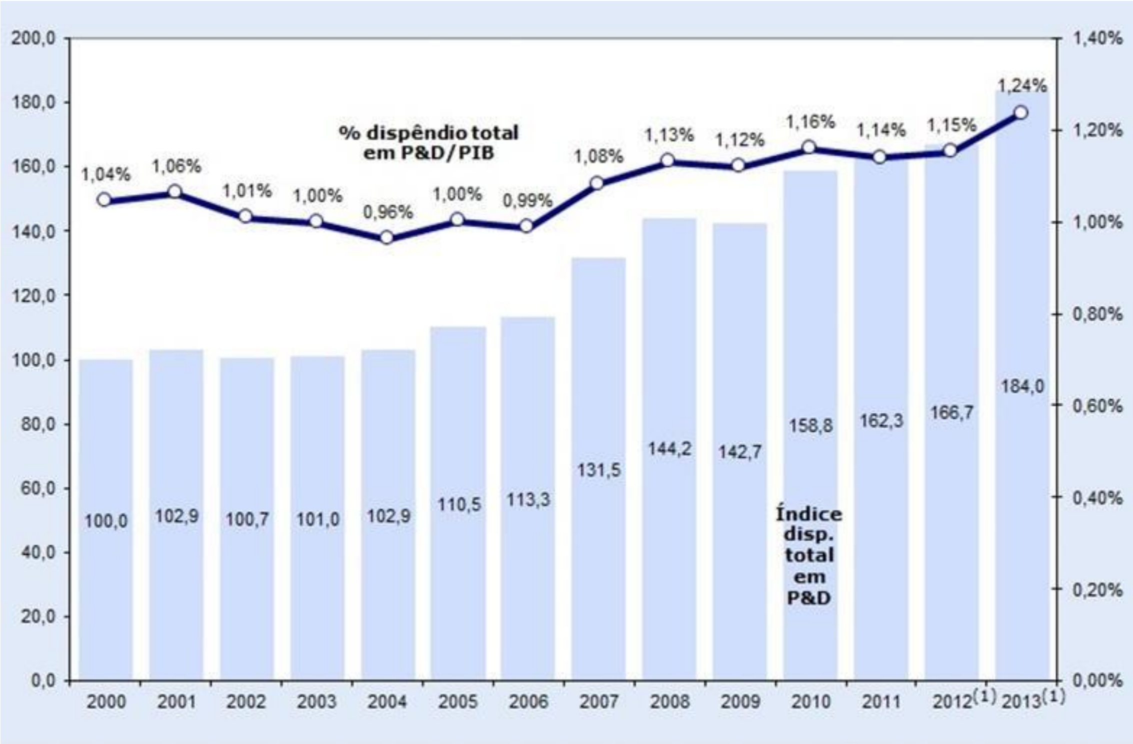
Chart 3. Expenditures on R&D, value of 2013, and expenditures on S&T as percentage of GDP from 2000 until 2013.



Source: MCTI

The real growth rate of expenditure on R&D, however, according to Chart 4, is 84% from 2000 to 2013.

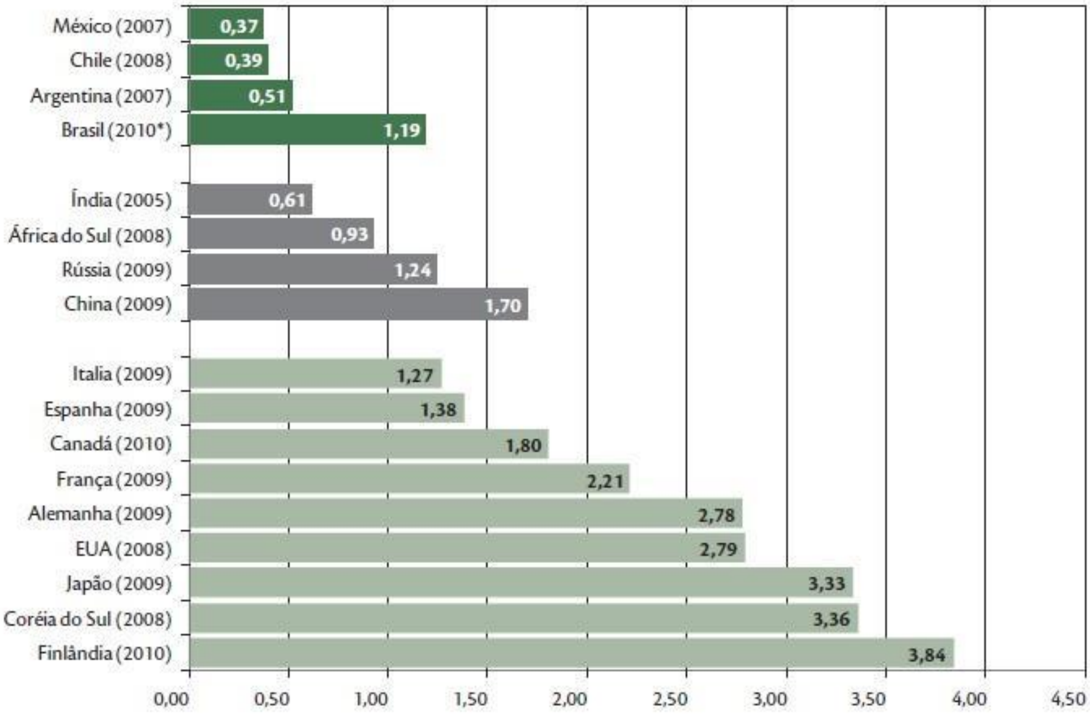
Chart 4. Real growth rate of expenditure on R&D and the percentage of total R&D expenditure in relation to GDP, 2000-2013.



Source: MCTI

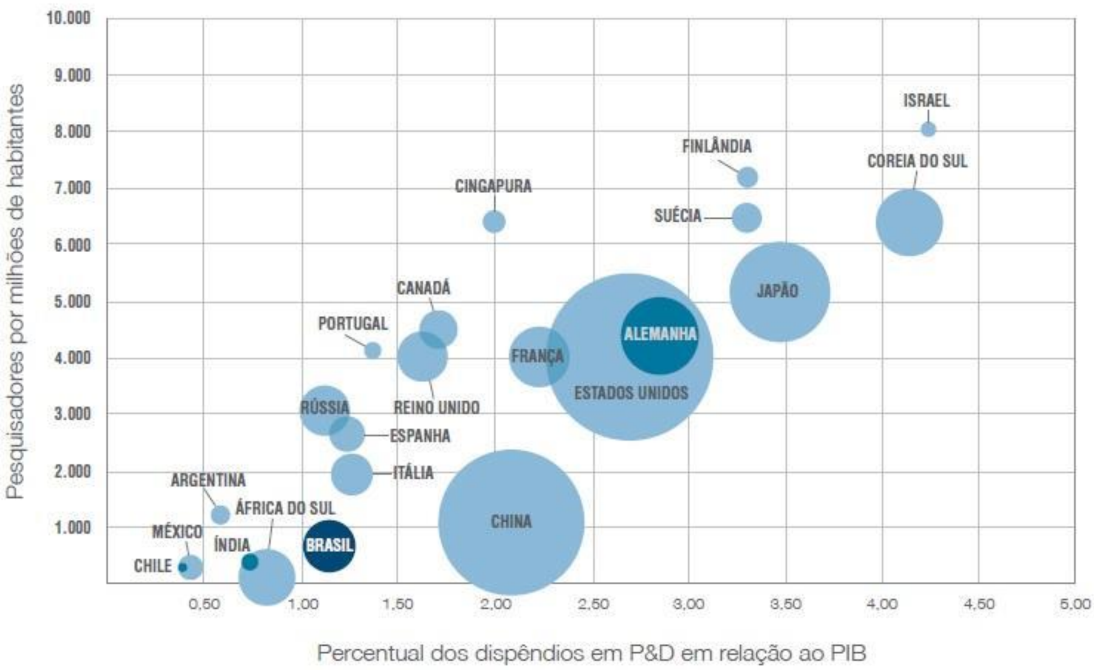
When comparing these numbers in the international scenario, these numbers express two different yet comparing perspectives. Charts 5 and 6 show how these recent improvements in the country’s expenditure on R&D has put Brazil in an outstanding position when compared to other Latin American countries. When examining the gross national expenditure back in 2010, Brazil had an R&D relation to GDP of 1,19%. In comparison to other countries such as Mexico’s 0,37%, Chile’s 0,39% and Argentina’s 0,51%, Brazil holds a leading position as an R&D leader in the region. When compared with the BRICS, Brazil remains average with 1,19%, as India and South Africa only had 0,61% and 0,93% respectively. Russia, on the other hand, had 1,24% and China led the block with 1,70%. Brazil, however, still has a long road ahead if it ever hopes to converge its technological efforts to the level of the most developed countries. According to the most recent data of 2014, Germany, had a R&D expenditure of 2,88% in relation to its GDP (BMBF, 2016). France also presented a R&D expenditure of 2,21% in relation to its GDP in 2009, the USA 2,79% in 2008, Japan 3,33% in 2009, South Korea 3,36% in 2008 and Finland 3,84% in 2010! (MCTI, 2012)

Chart 5. Gross national expenditure on R&D in relation to GDP of selected countries.



Source: MCTI (2012, p. 46)

Chart 6. Expenditure on R&D/GDP and researchers per million inhabitants.



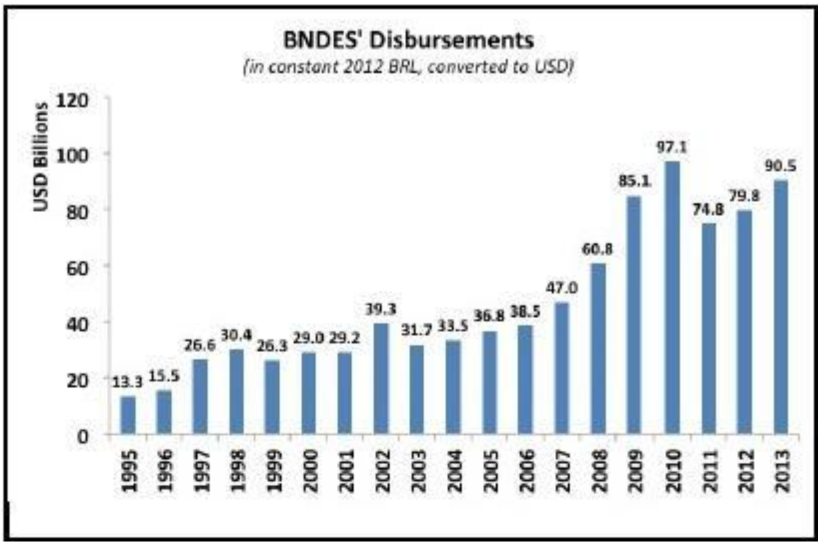
Source: MCTI (2016, p. 64)

When examining the post-2008 international scenario, Brazil was part of a group of countries on which the crisis had a different effect. Instead of cutting expenditures, a series of additional programs were announced, as an active and aggressive anti-cyclical policy of state-owned enterprises and governmental institutions:

> “The Brazilian government stepped it up through the Program for the Sustainability of Investments (PSI), which augmented tax incentives and the availability of credit by transferring resources from the Treasury to BNDES. This decision resulted in increased disbursements by BNDES, including the supply of short-term finance (e.g., working capital) for companies facing liquidity problems. In order to promote innovation investments.” (MAZZUCATO; PENNA 2015, p. 13)

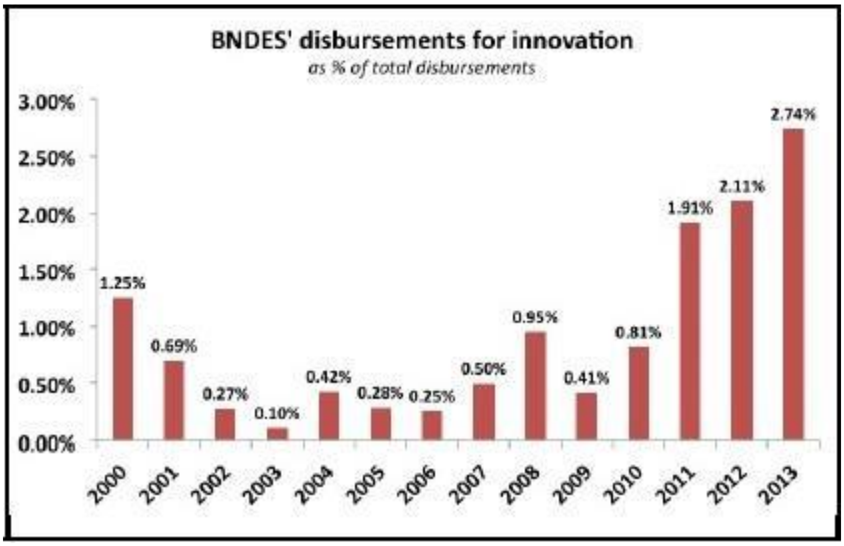
In addition to these announcements, BNDES started to offer subsidized credit for innovation projects. For companies who invest in innovation and fulfill additional requirements, BNDES offers a credit at an interest rate of 3.5% per year and postponed the terms of payment to 120 months. (BNDES, 2013) As Chart 7 shows, BNDES expenditures increased significantly during the 2000’s and, specifically, after the 2008’s crisis. Back in 2000, total expenditures estimated at US$ 29 billion, however in 2013, total expenditures increased to an amount of US$ 90,5 billion. Under the category of total expenditures, the amount given to innovation has also increased significantly during this period. While total expenditure for innovation was oscillating between 0,10% and 0,60% of GDP in the mid-2000’s, the latest data for 2013 shows that these expenditures reached 2,74% of BNDES’s total expenditure, as represented graphically in Chart 8.

Chart 7. BNDES's total disbursements, in values from 2012, 1995-2013.



Source: MAZZUCATO; PENNA (2015, p. 13)

Chart 8. BNDES's total disbursements for innovation, in values of 2012, 2000-2013.



Source: MAZZUCATO; PENNA (2015, p. 13)

Brazil national scenario presents a significant evolution of research projects and research institutions at universities and the degree in which it interacts with the productive sector for the period of 2002 to 2010. Back in 2002, there were 15.158 research institutes, but by 2010 that number rose to 27.523; representing an increase of 81,57%. Of that total number, 1.279 research institutes had an interaction with the productive sector in 2002. By 2010, that number increased to 3.506, representing a 174,12% increase in just 8 years. In other words, the degree of interaction between research institutes and the productive sector rose from 8,44% in 2002, to 12,37% in 2010 confirming an increase in interaction between the two. Naturally, there is an endogeneity problem in the sense that many things could have contributed to the increase in the level of importance of research groups and its interaction with the productive sector, but, R&D is definitely reaching a more relevant scale in Brazilian R&D and Innovation policy. (CNPq, 2015; SIMONINI, 2010)

Thus this great progress, Brazil is confronted with great challenges in the development of the Brazilian NIS due to the legal framework. In this context, significant improvements contributed to it since 2004 with the introduction of the Lei de Inovação Tecnológica – Technological Innovation Law (LIT) – (federal law nº 10.973 of 02.12.2004) and in 2005 with the introduction of the Lei do Bem – federal law 11.196/05.

The Federal Law nº 10.973/04 established a new legal framework to encourage innovation and scientific & technologic research and to enhance the interaction between the many national ST&I actors, especially improving the private investments in R&D. Additionally, the federal law nº 11.196/05 offers fiscal incentives to innovative firms. Both laws aim towards improving the efforts to building capabilities to develop technology and to create technological autonomy of firms acting in the Brazilian market, in order to promote economic development.

Since the introduction of the law 10.973/04, the regulation of the national economy has presented a slow development into a more consistent National Innovation System. The reform of the legal framework has already contributed to the improvements in the interaction between University-Enterprise relation, results of R&D and innovation processes. These improvements are the result of improvements in regulation of the appropriation of knowledge, as well as improvements in ST&I financing, as far as it allows development banks to launch higher funding to more audacious innovation projects – considering longer financing condition, risk-sharing opportunities and the requirement to involve many disciplines in the same project. (RUIZ DIAZ, 2013; SIMONINI, 2010)

On January 11th 2016, the former president Dilma Rousseff sanctioned a new legal framework for Science Technology and Innovation[8]. This new legal framing makes the interaction between universities, research institutes and the productive sector more

[8] http://blog.planalto.gov.br/dilma-sanciona-marco-legal-da-ciencia-tecnologia-e-inovacao/

flexible. The intention is to allow the institutional conditions for a more intense interaction between the diverse R&I actors, bringing them closer to one another, to allow more agility and to simplify the bureaucracy that make the innovation process and integrated actions between private and public actors more difficult. It stimulates a more intense international personnel exchange and mobility, as well as a greater support to the implementation of technological parks[9].

In addition to the sanction of the new legal frame to ST&I, the Federal government also launched the Universal 2016, which, through CNPq, will designate R$ 200 million to S&T research projects in any area of knowledge that contributes to the socioeconomic development of the country[10]. Not only the legal framework, but more financing networks and governmental institutions, significantly contributed to the improvement of the Brazilian NIS:

> "A construção de um ambiente propício ao investimento em inovação no País foi beneficiada não apenas por iniciativas como o Plano Brasil Maior (PBM), os INCT, o Plano Inova Empresa, o Sistema Brasileiro de Tecnologia (Sibratec) e a nova Empresa Brasileira de Pesquisa e Inovação Industrial (Embrapii), mas também pela melhoria no arcabouço legal e institucional para a comercialização e colaboração em PD&I entre academia e indústria[11]" (MCTI, 2016, p. 9)

In 2012, the European Commissioner for Trade stated that Europe is already Brazil's biggest trading partner, making up 22% of its total trade. In the last chapter, BMBF had also stressed that Brazil **is** Germany's greatest economic partner. Europe is also the largest investor in Brazil, holding more than 40% of the total foreign investments back in 2009. Europe's investment stock in Brazil exceeds its investments in China and India combined. This fact put Brazil at an outstanding position as it claims the European Union's attention. Brazil started to be seen under these and other factors as an important and potentially strategic partner for international policy, ST&I internationalization partner and cooperation for development. (ECT, 2012)

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9 http://blog.planalto.gov.br/ministro-destaca-avancos-que-novo-marco-legal-traz-para-pesquisadores-e-instituicoes/

10 http://blog.planalto.gov.br/dilma-sanciona-marco-legal-da-ciencia-tecnologia-e-inovacao/

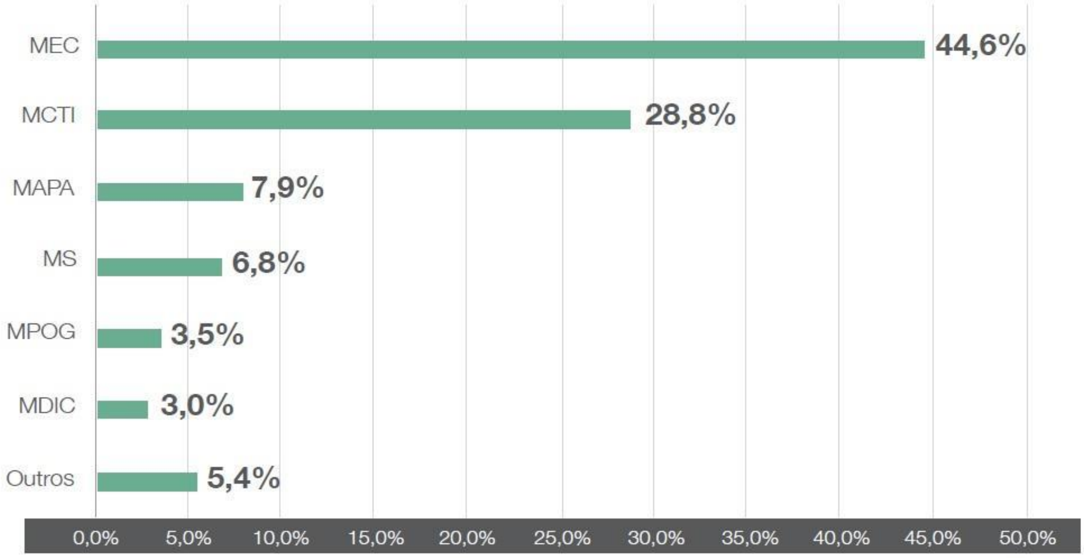
11 "The construction of a stimulating environment for investments in innovation in Brazil was possible not only because of initiatives like Plano Brasil Maior (PBM), the national institutes of technology, the Plano Inova Empresa, the Brazilian System of Technology (Sibratec) and the new Empresa Brasileira de Pesquisa e Inovação Industrial (Embrapii), but also due to improvements in the legal and institutional framework for commercializing and cooperating in RD&I between universities and industry." (MCTI, 2016, p. 9, own translation)

Regarding the Brazilian National Innovation System, it is relevant to briefly describe its structure. Actors of the Brazilian National Innovation System are divided into three categories: political institutions, financing institutions, and operators of science, technology and innovation. The first group is composed of the executive power, legislative power and agents of the society – for example, industrial associations, SMEs associations, etc. The second group is composed of five actors: CNPq, CAPES, FINEP, BNDES and FAP. The third group can be categorized as universities, research institutes of the Brazilian department of ST&I, federal research institutes, national institutes for ST&I (INCT), ST&I institutions (ICT), firm incubators, technological parks and innovative firms. (MCTI, 2016, p. 18)

At the governmental level, ST&I financing comes from four different institutions. First, financing comes directly from the federal government's budget; also from resources of the federal financing agencies; the budget of every unit of the federation; and resources managed by regulatory agencies. The federal government's budget is furthered divided into the Department of ST&I (MCTI), the Department of Education (MEC), the Department of Agriculture (MAPA), the Department of Health (MS), the Department of Development, Industry and Commerce (MDIC) and the Department of Defense (MD) (MCTI, 2016).

The governmental expenditure on ST&I has grown significantly since 2000, when the total gross expenditure was R$ 5,8 billion. In 2013, this amount reached R$ 32,9 billion, more than six times the amount of 2000 and still 24,6% higher than the expenditure of 2012. However, these investments are 73,4% concentrated within the expenditures from the Department of Education and the Department of ST&I, according to data on governmental expenditure for 2013 (MCTI, 2016), as illustrated in Chart 9.

Chart 9. Relative distribution of governmental expenditure on Science, Technology and Innovation (ST&I), per institution, in 2013.



Source: MCTI (2016)

In addition to the above mentioned funding actors, the MCTI (2016) also stresses the importance of foreign investment in ST&I from organisms and programs for international cooperation, such as Horizon 2020, the Newton Fund, the Prosperity Fund, the Global Environment Facility, the German Climate and Technology Initiative, the International Climate Initiative, among others (MCTI, 2016). Recently, on January 22th 2016, the New Development Bank (NDB), as an alternative to the World Bank and the IMF, started as a new actor funding international R&D cooperation funds between the BRICS. The NDB's fund for ST&I totals R$ 24 million, of which Brazil contributed R$ 1,2 million[12].

4.3 Brazilian National Strategy for Science Technology & Innovation and its Internationalization.

> "A definição de estratégias para emparelhamento com as nações mais desenvolvidas passa pelo fortalecimento dos think tanks nacionais que, produzindo e difundindo conhecimentos sobre assuntos estratégicos, são capazes de identificar tendências e propor ferramentas que contribuam

[12] http://www.mcti.gov.br/noticia/-/asset_publisher/epbV0pr6eIS0/content/brics-cria-fundo-de-r-24-milhoes-para-financiar-projetos-conjuntos-de-pesquisa

> para a tomada de decisão sobre investimentos domésticos e de cooperação internacional.[13]" (MCTI, 2016, p. 63)

Strategic thinking is crucial in modern society. A nation's development requires identifying global trends, guaranteeing constant investments and elaborating a long-term plan, in order to identify structural barriers in development, to identify challenges, develop and elaborate a strategy to overcome these barriers. A national strategy is essential for defining a set of instruments supporting the national ST&I actors and for directing efforts towards expanding, solidifying and integrating the most heterogenic actors in a National Innovation System (MCTI, 2016). In this context, the Brazilian Department of Science, Technology and Innovation identified five challenges for developing its National Science, Technology and Innovation:

i. To put Brazil among the most developed countries in ST&I;
ii. To improve institutional conditions, aiming to enhance innovation's productivity;
iii. To reduce regional asymmetries in production and in accessing ST&I;
iv. To develop creative innovations for social inclusion and;
v. To strengthen the basis for promoting sustainable development;

A strategy that aims to economically catch up with the most developed countries in the world– mentioning the example of the strategies exposed in chapter 3 – must elaborate a series of instruments to improve an industry's competitiveness. In MCTI (2016), these instruments focus on innovation-driven activities, as knowledge is an important input into the production process, with instruments to foster innovative investment in the high-tech branches of industry.

> "As estratégias para o aumento da competitividade econômica das nações estão fortemente relacionadas com as estratégias de avanço da inovação. Para que os resultados pactuados com a sociedade nesses temas sejam alcançados estão sendo empreendidos diversos esforços para fortalecer e expandir os SNCTIs[14]" (MCTI, 2016, p. 51)

[13] "Defining strategies aiming to catch up with the most developed nations must be guided by strengthening the national think tanks that are capable to identify trends and suggest instruments that, producing and diffusing knowledge about strategic issues, contribute to decision-making regarding domestic investments and international cooperation" (MCTI, 2016, p. 73-81, own translation).

[14] The strategies that aim towards increasing the economic competitiveness of nations are strongly related to the innovative progress. In order to achieve the results agreed between policy-makers and society, diverse efforts are being taken to strengthen and expand the National Innovation System (MCTI, 2016, p. 51, own translation)."

Elaborating on the previous section, Brazil has taken some steps towards improving its NIS. The Action Plan 2007-2010 (MCTI, 2007), followed by the ENCTI (MCTI, 2012), executed and established a National Policy in ST&I. Both programs contributed to improvements in Brazilian ST&I such as: a) qualifying human resources; b) improving R&D infrastructure; c) improving instruments responsible for promoting R&D; d) increasing scientific publications; e) contributed to the mobility of qualified researchers beyond of the Southeastern Region, and; f) expanded and diversified funding to innovative firms (MCTI, 2016, p. 37).

Parallel to this above mentioned progress, the Federal Government has worked towards improving the legal framework. Nonetheless, the ENCTI sees the importance of investing in building research infrastructures and claims it "must be taken as a priority in the National Science, Technology and Innovation System" (MCTI, 2016, p.9).

Regarding human resources, qualifying the national researchers' community has been a priority since the creation of its main instrument: Ciência sem Fronteiras (CsF), also known as Science without Borders. The program's goal is to consolidate funding for internationalizing Brazilian researchers as well as strengthening international scientific and technologic cooperation with other countries (MCTI, 2012). CsF is an important instrument to internationalize Brazilian research (MCTI, 2016).

The national program for mobility of Brazilian researchers, CsF, is the main focus of the MCTI, in partnership with the Department of Education (MEC), to qualify their researchers. CNPq as well as CAPES, two Brazilian institutions under the command of the MCTI and MEC, execute the CsF. This mobility program promotes the qualification of Brazilian researchers to the best universities around the world and aims to achieve scientific excellence. It enables researchers to elaborate a network and facilitate future international cooperation for Research and Development. The mobility program is an important step towards internationalizing the Brazilian research. First, it facilitates the formation of high quality Brazilian researchers. Then, it attracts international researchers to Brazil, in order to incorporate Brazilian research with the best quality research around the world. (MCTI, 2012; B.BICE, 2015; MCTI, 2016)

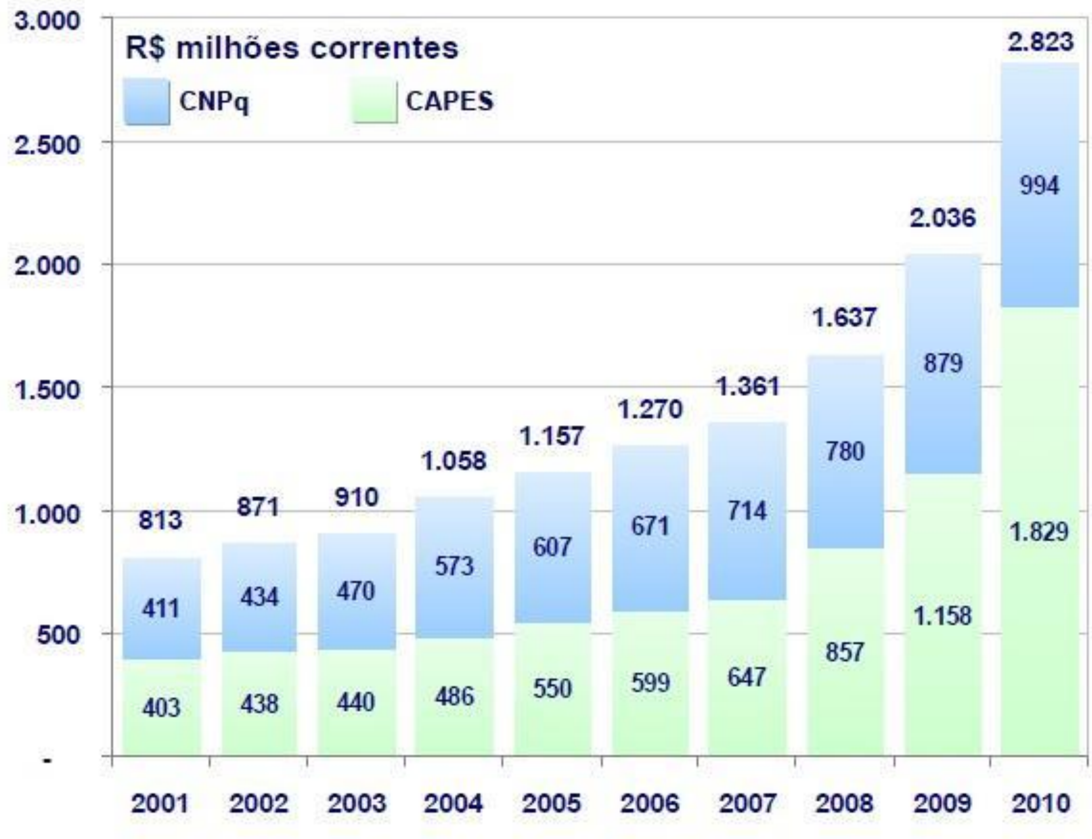
> "No intercâmbio de recursos humanos para CT&I, destaca-se o Programa Ciência sem Fronteiras (CsF). Esse Programa representa um avanço na internacionalização da pesquisa brasileira ao enviar estudantes brasileiros para

> cursos nas mais renomadas universidades do mundo, conferindo a eles formação de qualidade em áreas tecnológicas consideradas prioritárias como: Engenharias, Ciências da Vida e da Saúde, Tecnologia da Informação e Energia. Além disso, o CsF atua também na atração de pesquisadores do exterior com o objetivo de aproximar a produção científica nacional daquela realizada em alto nível em centros de pesquisa de classe mundial[15].” (MCTI, 2016, p. 9)

Chart 10 illustrates the evolution of CNPq and CAPES’s expenditure on scholarships between the years 2001 and 2010. The total expenditure on scholarships in 2010 was 3,5 times higher than the expenditure on scholarships in 2001. CAPES’s expenditure had the highest increase over the decade, 353%, and sums R$ 1,829 billion by 2010**.** While CNPq’s expenditure increased 141% to a total sum of R$ 994 million in scholarships.

[15] “Among the exchange programs for human resources in ST&I, the program Science without Borders stands out. This program represents progress in the internationalization process of Brazilian research, while sending Brazilian researchers to study at the best universities in the world, allowing them access to high-quality formation in technological areas considered as priority, such as: engineering, health sciences, information technology and energy. CsF intends to attract foreign researchers, aiming to approximate the national scientific production to the ongoing scientific production in research centers that are global reference” (MCTI, 2016, p. 9, own translation)

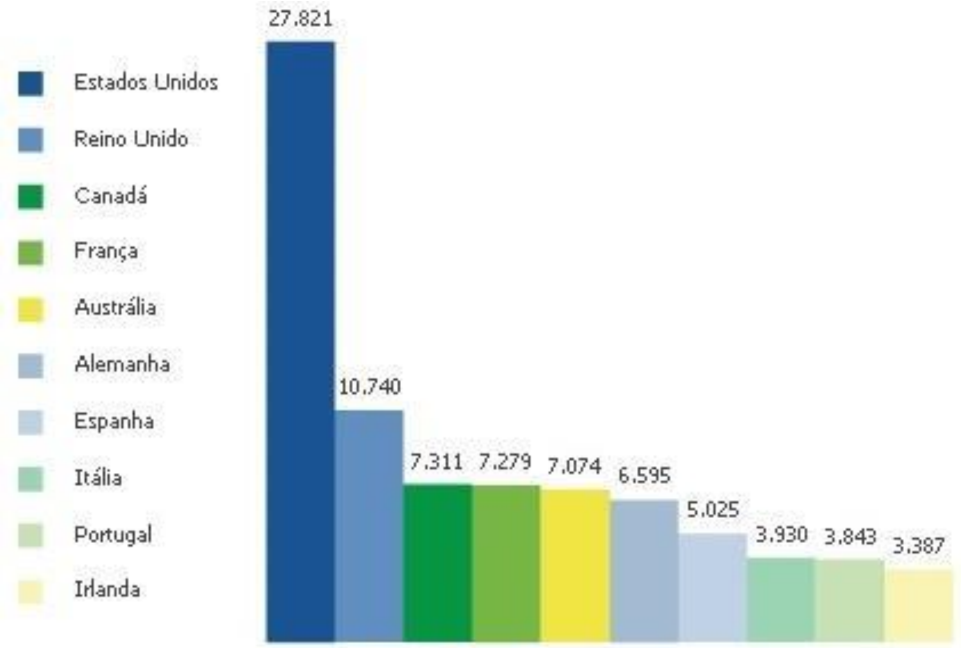
Chart 10. Expenditure on scholarships by CNPq and CAPES, 2001-2010 (R$ millions, value of 2010).



Source: MCTI (2010, p. 24)

Chart 11 shows the distribution of granted scholarships per country under the program CsF. The scholarships are highly concentrated in the USA, with 27.821 scholarships granted in 2016. This represents 33,51% of the top-10 countries' granted scholarships. Other top countries included, the United Kingdom with 10.740 scholarships (12,93%), Canada with 7.331 (8,83%), France with 7.279 (8,76%), Australia with 7.074 (8,52%), Germany with 6.595 (7,94%), Spain with 5.025 (6,05%), Italy with 3.930 (4,73%), Portugal with 3.843 (4,62%) and lastly Ireland with 3.387 (4,08%). These remaining 9 European countries represent 49,15% of the total number of scholarships granted, compared to the 33,51% of the US alone.

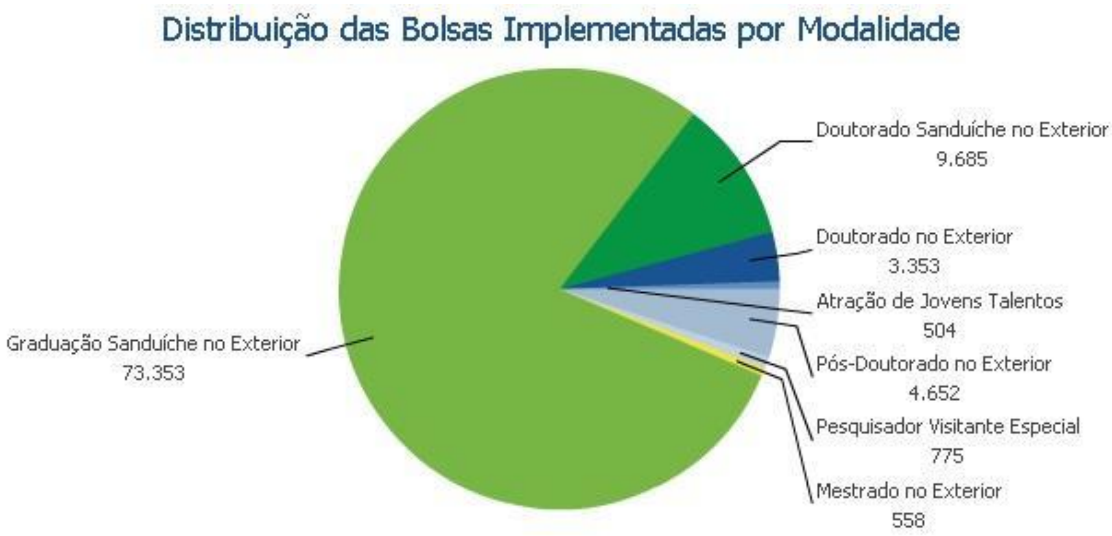
Chart 11. Distribution of granted scholarships per country. January 2016.



Source: http://www.cienciasemfronteiras.gov.br/web/csf/painel-de-controle

In 2015, 92.880 scholarships were granted to the CsF program per modality. In total, 73.353 (78,97%) were granted to Undergraduate Programs, of which one year was studied abroad. Only 558 (0,6%) scholarships were granted to full Graduate Master's Program. For Graduate PhD programs, of which half of it was taken abroad, 9.685 (10,42%) scholarships were granted. A total of 3.353 (3,6%) scholarships went to Full Graduate PhD programs and 4.652 (5%) were granted to Full Post-PhD Programs. The CsF program for attraction of Youth Talents granted scholarships to 504 students (0,5%) and finally 775 (0,8%) scholarships to Special Visitor Researchers. All in all, the Brazilian mobility program, CsF, grants 78,97% of its scholarships to undergraduate students and only 19,64% to graduate programs (Masters, PhD and Post-PhD).

Chart 12. Distribution of granted scholarships per modality. January 2016.



Source: http://www.cienciasemfronteiras.gov.br/web/csf/painel-de-controle

Even though only 19% of the scholarships under the program CsF were granted to graduate programs, the number of graduated researchers significantly grew. The number of yearly completed graduate programs increased from 13.484 in 1996 to 50.168 in 2009. That is a 272% increase from 1996. When disaggregating this number, it is evident that the graduate master program grows at a much faster pace than the graduate PhD program, with linear coefficients of 2238.6 (R^2=0.987) and 655 (R^2=0.994), respectively.

Chart 13. Number of graduated, masters and PhD, per year and adjusted curve, 1996-2009.

Source: MCTI (2010, p. 27)

The Brazilian National Strategy for Science, Technology and Innovation (ENCTI) for 2016-2019 has five structuring points that base the expansion, consolidation and integration of the Brazilian NIS, focusing in research, research infrastructure, financing, human resources and innovation (MCTI, 2016):

1) Promoting basic scientific and technological research;
2) Fostering the modernization and improvements in ST&I infrastructures;
3) Broadening financing to support the development of ST&I;
4) Qualifying, attracting and settling human resources in the country and;
5) Promoting technological innovation in firms" (MCTI, 2016, p. 73-81).

The ENCTI 2016-2019 stresses and supports the progress done towards expanding, consolidating and integrating the Brazilian NIS. In order to improve, investments in ST&I must be constant and continuous to guarantee the continuity of programs that are essential for the development of the national ST&I. The evolutionary and cumulative character of innovation processes, require this continuity in investment as well as in scientific and technologic development. The MCTI (2016) emphasizes the argument, guaranteeing the focus on the continuity of financing and supporting innovation programs:

> "Consolidar o SNCTI também significa identificar e promover ações para que instrumentos de financiamento, recursos humanos e infraestruturas, considerados estratégicos, continuem operando. A desmobilização, ainda que temporária, desses recursos poderá retardar avanços importantes do setor e, em situações extremas, provocar a perda de competências alcançadas por meio de longos de anos de trabalho realizado por cientistas, gestores e empresários inovadores[16]" (MCTI, 2016, p. 73)

In this context, the ENCTI 2016-2019 has set some goals to be reached by 2019 whose aim is to guarantee and expand current investment levels. Table 6 shows the ambition to increase the national expenditure on R&D to 2% of GDP, departing from 1,24%, while supporting private investments on R&D expecting a 73% growth of private investments in the sector and a growth of 54% in public investments in R&D. The

[16] "Consolidating the National System of Science, Technology and Innovation also means identifying and promoting actions to guarantee the continuation of funding instruments, human resources and research infrastructures, which are considered strategic. Dismantling, even if temporary, these resources can delay important progress in ST&I and, in extreme situations, it can cause the loss of capabilities acquired over the course of many years of work done by scientists, managers and innovative entrepreneurs" (MCTI, 2016, p. 73, own translation).

participation of firms in innovative processes is one of the goals of the ENCTI 2016-2019. It is reflected in the goal of supporting the business innovation rate grow from 35.7% to 48.6% and, consequently, keeping these innovative firms investing continuously in R&D. The number of researchers per million of inhabitants is expected to triple by 2019, while the number of graduated students is expected to grow almost 5% in relation to all graduates.

Table 6. Monitoring Indexes and Goals for 2019.

	Indexes	Last Official Index and correspondent year	2019 goal
1	National expenditure on R&D as proportion of GDP	1,24% (2013)	2,00%
2	Entrepreneurial expenditure on R&D as proportion of GDP	0,52% (2013)	0,90%
3	Governmental expenditure on R&D as proportion of GDP	0,71% (2013)	1,10%
4	Federal governmental expenditure on R&D as proportion of GDP	0,50% (2013)	0,80%
5	Business innovation rate	35,7% (2011)	48,6%
6	Number of businesses investing continuously in R&D	5.600 (2011)	10.000
7	Percentage of innovative businesses that use at least one of the governmental instruments for supporting innovation in businesses	34,2% (2011)	40,0%
8	Number of technicians and researchers employed in R&D in businesses	103.290 (2011)	120.000
9	Percentage of graduated engineering students in relation to graduates in all areas	7,2% (2013)	12,0%
10	Number of researchers per million of inhabitants	709 (2010)	2.100

Source: MCTI (2016, p. 111)

Unlike MCTI (2012), the recently published MCTI (2016) does not present a special section of the ENCTI setting goals and guidelines towards an internationalization of the Brazilian ST&I. Nevertheless, even though, there is no section dedicated exclusively to the internationalization, the strategy points guidelines, or improvements and goals towards internationalizing Brazilian research and researchers.

The ENCTI 2016-2019 claims international cooperation is a global trend and is necessary to enhance the competitiveness of the national industry, as well as to keep up with innovative scientific research on the *knowledge frontier*.

> "Em um contexto de globalização, as políticas públicas e iniciativas privadas de países em desenvolvimento têm sido orientadas para a conformação de trajetórias de emparelhamento baseadas tanto na *cooperação como na competição internacional*[17]" (MCTI, 2016, p. 17)

The international priorities of the ENCTI 2016-2019 are concentrated on building innovation capabilities in national firms, also enhancing their competitiveness internationally through innovation as well as qualifying Brazilian researchers, through international mobility. International scientific cooperation "is also essential when creating capabilities of Brazilians nationally and internationally, contributing to the qualification of people and to promoting Research Development & Innovation" (MCTI, 2016, p. 79).

Nonetheless, the global trend not only develops towards increasing the competitiveness of national industries and international cooperation in research, but it also focuses on tackling global challenges, such as climate change, population aging and development. That is why the ENCTI 2016-2019 focuses on enhancing international cooperation, in order to promote interdisciplinary research to tackle global challenges effectively:

> "Verifica-se, também como tendência, o fato de as iniciativas de excelência em pesquisa apresentarem um crescente componente internacional. Nesse sentido é que os financiamentos à pesquisa voltados para a colaboração internacional têm sido pautados por arranjos mais flexíveis, que sejam capazes de incorporar parceiros internacionais ao se admitir que alguns resultados não podem ser alcançados apenas com esforços domésticos." (MCTI, 2016, p. 53) (...) "A pesquisa pública tem sido reforçada em abordagens interdisciplinares voltadas a soluções de grandes desafios como mudanças do clima, envelhecimento da população e desenvolvimento[18]." (MCTI, 2016, p. 54)

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[17] "In a globalization context, public policies and private initiatives of emerging countries have been oriented to converge with trajectories based on international cooperation as well as on international competition" (MCTI, 2016, p. 17, own translation).

[18] "It is a clear trend in excellence science to present a highly international component. In this sense, funding to international research develop must have more flexible frameworks, in order to allow the incorporation of international partners, once admitted that some results cannot be achieved only with domestic efforts" (…) "public research has been reinforced with interdisciplinary approaches, aiming to find solutions to

The Department of Science, Technology and Innovation strongly supports international mobility. The mobility program CsF was vehemently supported and presented significant results, as argued previously. As the main instrument of the ENCTI 2016-2019, the CsF presents promising goals towards connecting Brazilian researchers with the world's best researchers and research infrastructures abroad, in order to promote excellent scientific research in Brazil:

> "A internacionalização da ciência brasileira, fortalecida por meio do programa Ciência sem Fronteiras, deve ser pautada pelo acesso direto de pesquisadores a trabalhos realizados em países desenvolvidos, pela integração global desses pesquisadores e pela promoção da pesquisa de excelência no Brasil[19]." (MCTI, 2016, p. 79)

A solid National Innovation System in Brazil depends on the formation, attraction and settling of qualified human resources. Qualified researchers should work in institutions, which are willing to cooperate in R&D projects nationally as well as internationally, therefore contributing to high-quality scientific and technologic research (MCTI, 2016).

Finally, the goals for internationalizing Brazilian R&D in the ENCTI 2016-2019, started with guidelines set by MCTI (2010), but consequently were strongly supported by MCTI (2012). These goals focus on facilitating the formation, attraction and settling of qualified human resources, paying special attention to the mobility of Brazilian researchers, aiming to avoid a *brain drain*. Furthermore, the ENCTI 2016-2019 aims to support the internationalization process of Brazilian firms, to facilitate their investments in innovation, to support the openings of multinationals R&D centers in Brazil and to improve technology transfer processes:

> "Incluem-se nas ações necessárias à consolidação desejada o fomento à internacionalização da ciência e dos cientistas brasileiros e o fortalecimento das atividades de cooperação científica e tecnológica com outros Países e regiões. Cumpre também apoiar a internacionalização das empresas brasileiras e a aquisição de ativos tecnológicos no exterior, atrair centros de P&D de empresas multinacionais para o

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important global challenges, such as: climate change, aging of the population and development". (MCTI, 2016, p. 53-54, own translation).

[19] The internationalization of Brazilian science, strengthened by the program Science without Borders, must be based on guaranteeing Brazilian researchers access to works done in developed countries, based on the global integration of these researchers as well as based on the promotion of excellence research in Brazil" (MCTI, 2016, p. 79, own translation).

> Brasil e incentivar os processos de transferência de tecnologia[20].” (MCTI, 2012, p. 38)

4.4 Brazilian participation in FP7 and H2020

ENCTI 2016-2019 does not present a clear, wide and articulated strategy for the *internationalization* of Brazilian ST&I that goes beyond the formation and mobility of human resources. However, statistic data and monitoring documents show that international cooperation for technological development happens more often than expected when considering the national strategy for ST&I. In fact, the Brazilian government under the instruments of FINEP, CAPES and CNPq fosters international cooperation with Brazilian participants.

The B.BICE+ monitoring report concluded that the Brazilian researchers community is “very engaged in fellowship exchange with Europe, which proves an interest from both sides in cooperating in different areas and contributing to capacity building” (B.BICE, 2015, p. 96-7).

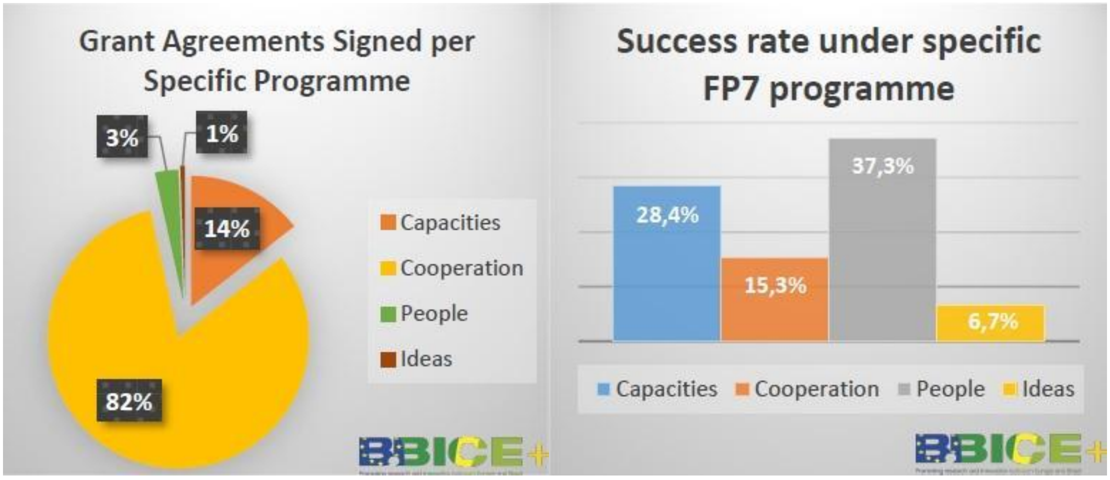
This section analyzes the Brazilian participation in the European Commission’s 7th Framework Program for R&D international cooperation and Horizon 2020. Some statistical data from the B.BICE+ study of 2015 as well as data from the CORDIS database will base the data analyzed in this section. The main focus is to characterize the Brazilian participation in FP7 and compare the Brazilian participation in H2020 with FP7.

In the European Commission’s FP7 for R&D, there were 1.364 submitted projects with at least one Brazilian partner. Among these 1.364 projects, only 173 were approved, which gives a success rate of 12,68%. However, these numbers do not include the Brazilian participation in the Marie Curie Action. If included, the Brazilian success rate increases to 21,34%, which shows the importance of the Marie Curie Action for the internationalization of Brazilian research (B.BICE, 2015). When compared with the overall average success rate of 20%, Brazil is just over the average with 21,34% (B.BICE, 2015).

[20] “The necessary actions to consolidate R&D internationalization include the desired funding for the internationalization of Brazilian science and Brazilian scientists and the strengthening of scientific and technologic cooperation activities with other countries and regions. It is also necessary to support the internationalization of Brazilian firms and the acquisition of technological assets abroad, attract R&D centers from multinational companies to Brazil and to encourage technological transfer processes” (MCTI, 2012, p. 38, own translation).

Chart 14 shows the approved projects with Brazilian partners. The area with the most granted assignments is the Cooperation Program (142), followed by Capacities (25), People (5) and Ideas Program (1). Concerning the success rate of the previous mentioned programs, the People Program presented the highest success rate with 37,3%. Through this data, it can be concluded that projects submitted for the People Program had a better quality and therefore a better success rate. The Capacities Program had a success rate of 28,4%, followed by Cooperation (15,3%) and Ideas (6,7%) (B.BICE, 2015).

Chart 14. Grant Agreements Signed per Specific Program and Success Rate under Specific Program in FP7, 2007-2013.



Source: B.BICE (2015)

Concerning the actors, the top-10 Brazilian institutions that participated in FP7 are somewhat heterogeneous. The top-10 list is composed of one private organization, EMBRAER. The others are High Education Institutions (USP, UFRJ, UnB, UNICAMP, UFMG), which represent half of the list, and Research Institutions (FIOCRUZ, EMBRAPA, FUSP and INPE). The institutions that submitted the best projects among the top-10, were EMBRAPA, INPE and FIOCRUZ, with 30,19%, 30,61% and 23,81%, respectively. USP, who submitted the largest number of projects for cooperation with FP7, showed to have the lowest success rate among the top-10 list, with 7,89 %. Nevertheless, it is the third institution with Grans Assignments in FP7 (B.BICE, 2015).

Table 7. European Evaluation Status for the first 10 Brazilian institutions participating at FP7.

Institution	European Evaluation Status								
	Mainlist	**Reserve**	**Rejected**	**Inelegible**	**Withdrawn**	**Without Evaluation Status**	**Total**	**GA Signed**	**Success Rate (%)**
EMBRAPA	13	17	19	2	1	1	53	16	30,19
FIOCRUZ	15	4	28	2	0	0	49	15	30,61
USP	42	13	127	5	0	3	190	15	7,89
UFRJ	31	11	64	1	1	2	110	11	10
INPE	13	2	26	1	0	0	42	10	23,81
FUSP	10	4	35	1	0	0	50	9	18
UnB	13	2	19	1	0	1	36	9	25
UNICAMP	17	7	41	1	0	1	67	8	11,94
EMBRAER	15	6	25	0	0	0	46	6	13,04
UFMG	11	1	39	1	0	0	52	6	11,54

Source: B.BICE (2015)

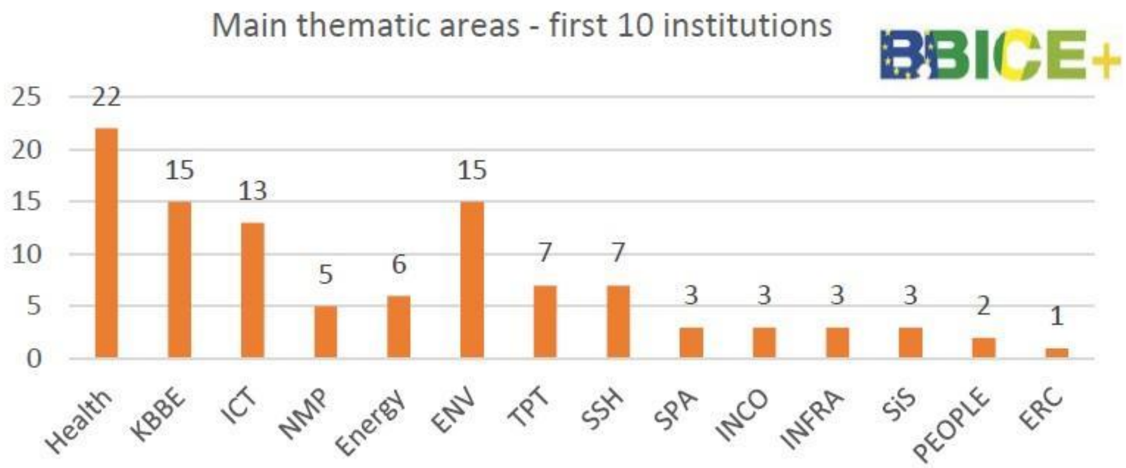
When extending the data to the Brazilian institutions with more than one Grant Assignment signed (Chart 15), the list expands to 31 institutions. Higher Education Institutions and Research Organizations are predominant in this list. The 430 institutions submitted 297 projects for international cooperation under FP7. The Higher Education Institutions represented 71 of the total, followed by Research Institutions (34), Private Organizations (27), Public Organisms (10) and 15 projects that classify as “others”. (B.BICE, 2015)

Chart 15. Brazilian Institutions with more than one Grant Assignment signed in FP7.

Source: B.BICE (2015, p. 38)

Once divided into thematic areas, the cooperation programs with the most projects signed were Health Programs with 22 grant assignments, followed by Food, Agriculture, Fisheries and Biotechnology (KBBE) with 15, Environment (ENV) with 15 and Information and Communication Technologies (ICT) with 13.

Chart 16. Main thematic areas of the Brazilian first 10 institutions participating in FP7.

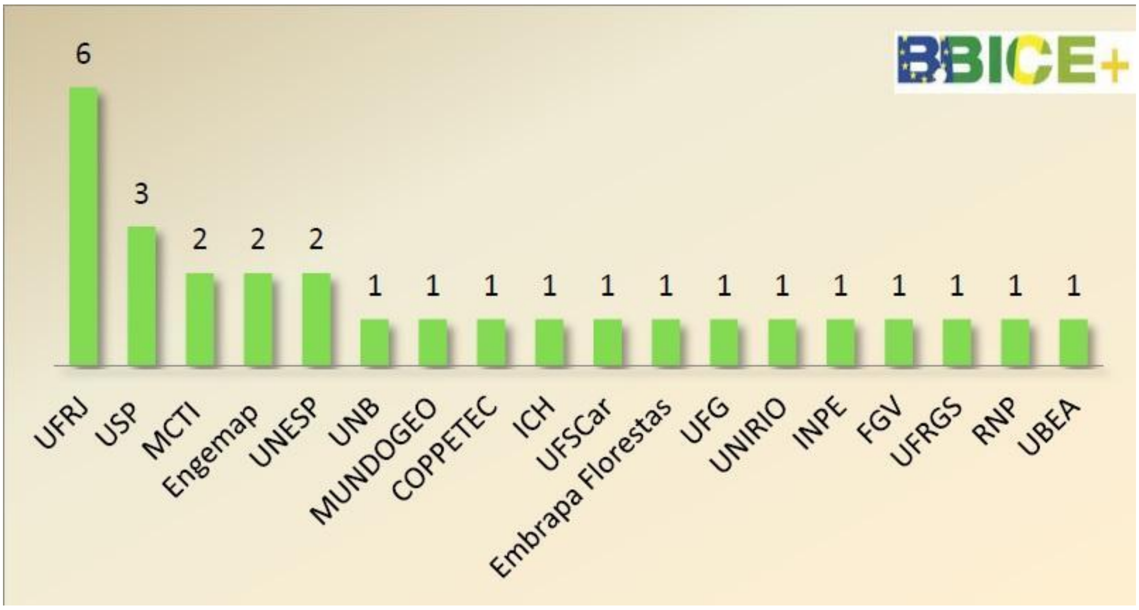


Source: B.BICE (2015, p. 40)

Changing our focus now to the Brazilian participation in H2020, the picture is very different. Comparing Chart 17 to Chart 18, one's first impression is that there was higher participation in FP7. From the institutions with more projects granted, only five have more than one grant agreement signed. In H2020, only UFRJ and USP appeared in FP7's top 10. (B.BICE, 2015, p. 66). EMBRAPA and FIOCRUZ did not have a single grant signed in Horizon 2020.

The report B.BICE (2015) evaluates the Brazilian participation in thematic projects in FP7 as positive and "corresponds to the main aspects from the Brazilian National Strategy for ST&I, which highlights TICs, renewable energy, climate change, Marine and Maritime science, Nanotechnology and Space as priority areas" (B.BICE, 2015, p. 96). The harmony between international cooperation for R&D and the ENCTI 2012-2015 is very important and expected to be satisfied between H2020 and the ENCTI 2016-2019 as well.

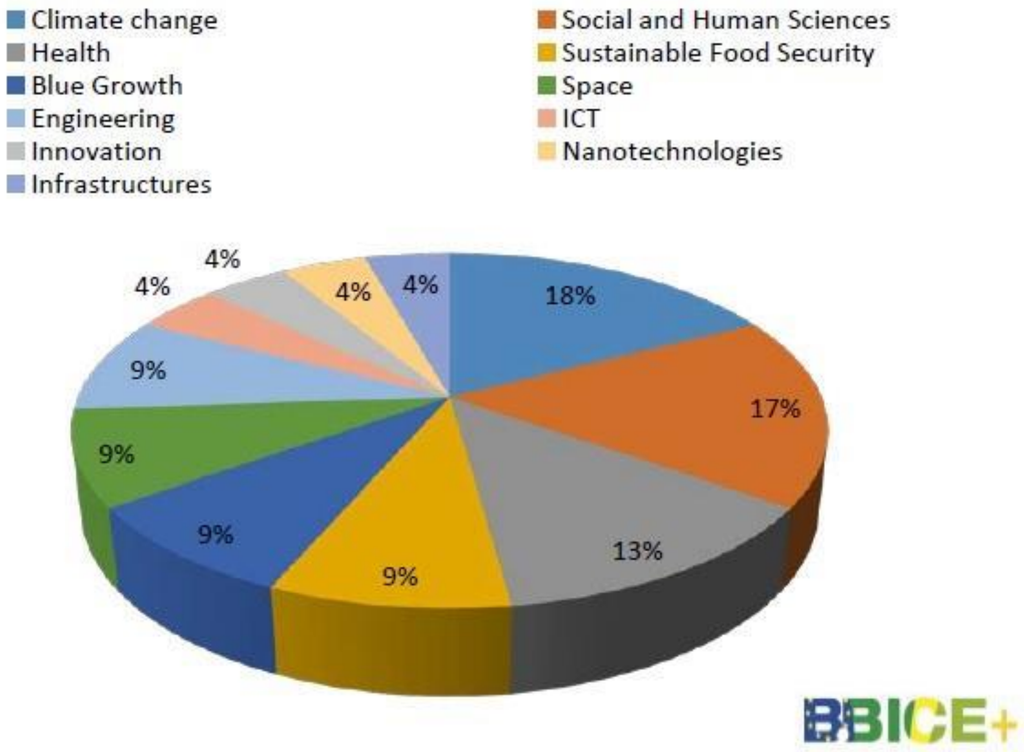
Chart 17. Brazilian institutions having signed a grant agreement under H2020.



Source: B.BICE (2015)

The thematic distribution of projects under H2020 presents another figure when compared to the thematic distribution under FP7. While under FP7 Health, KBBE and ICT represented the top three areas with the most participation, however, under H2020 Health represented only 13% of the grant agreements signed, ICT represented only 4% and KBBE is not even included. The area with the most grant agreements signed is Climate Change (18%). Surprisingly, the area that follows with the second most grants signed is Social and Human Sciences (17%), followed by Health (13%), Sustainable Food Security (9%), Blue Growth (9%), Space (9%) and Engineering (9%).

Chart 18. Thematic distribution of selected projects under H2020.



Source: B.BICE (2015)

For the year 2014, projects with Brazilian partners totals 83 applications for funding, of which 23 were accepted. This results in a success rate of 27,71%, which is higher than the 21,34% rate of success under FP7. Taking into consideration a greater context, the average success rate of all countries in FP7 is about 20%, which puts Brazil above average. However, the overall success rate under H2020 declined to 14%, which according to B.BICE (2015, p. 61) "shows that H2020 is a more selective program than FP7." Nevertheless, considering the overall average for H2020, Brazil has an outstanding position with an exceptional rate of success.

The Brazilian participation in H2020 has declined, though. While under FP7, an average of 42 projects were signed per year. Under H2020, only 23 projects were signed in 2014, despite the high success rate. One possible reason for this decline in participation of private institutions, as well as for the decline in proposals with Brazilian partners, can be the exclusion of Brazil as a partner with automatic funding. This shift is crucial in the transition from FP7 to H2020, when Brazil no longer fulfilled all requirements to receive automatic funding from the European Commission. Consequently, private participation diminished and international cooperation projects concentrated in public federal institutions, according to data presented by B.BICE (2015).

> “There were 91 Brazilian institutions involved in FP7 projects, with 220 contracts signed. A great majority is Higher Education Institutions and Research Institutions. This highlights the interest of these institutions in collaborating with European partners for the development of their researches. (...) The participation of Brazilian public institutions and actors from the private sector is still very limited.” (B.BICE, 2015, p. 97)

Furthermore, the data also presented a geographical concentration of participants in the Southeastern Region. This region had represented 64% of the grant agreements signed under FP7 and already represents 68% under H2020. The geographical concentration, as well as the low level of participation of Brazilian private institutions is a challenge and the Brazilian ENCTI 2016-2019 intends to promote private investment of innovative firms, especially regarding international cooperation.

Another important piece of data concerning the change of the Brazilian participation in FP7 and H2020 is that in FP7, Brazil was the fourth country with most grant assignments, among third countries. In H2020, Brazil is only the eighth. This too could very well be explained by the exclusion from the automatic funding.

> “Comparing the Brazilian participation with other third countries, Brazil is among the top ten, ranking eighth in terms of participations in applications submitted to the European Commission. This place shows a setback since FP7, for the country used to rank fourth.” (B.BICE, 2015, p. 99)

According to B.BICE (2015), other countries presented a significant decline in participation in H2020 as well. For instance, one can look at Russia and see that:

> “Brazil is not the only country whose participation has significantly decreased: the Russian Federation’s participation share used to score 0.5% while it is now around 0.1%. This sharp difference could be explained on Brazilian side by the fact that the E.C. does not finance Brazilian scientific teams anymore. Despite the lower participation in H2020, the Brazilian researchers remain among the main partners of European scientists in the third country category.” (B.BICE, 2015, p. 99)

5. Analysis of participation of Brazilian institutions in the international cooperation program for ST&I FP7 and Horizon 2020.

This final chapter aims to analyze the results obtained from the online survey[21] sent to Brazilian institutions that took part in national calls for ST&I projects between 2007 and 2016 (the target group). The survey was used to identify important aspects of the ongoing activities, difficulties and preferences that these institutions currently have. The ultimate goal of this research is to identify criteria and measures that could potentially lead to the improvement of international cooperation.

According to FINEP, 1,800 institutions were identified as active in national calls for ST&I, of which 1,500 were companies and 300 were S&T institutes. FINEP invited all 1,800 institutions to answer the survey. Additionally, there were another 45 institutions, that were found in the CORDIS database, but not on FINEP's list, that were included as well. Of the 1,845 total institutions that were contacted, 481 answered the survey, of which 234 are complete and 247 are considered incomplete.

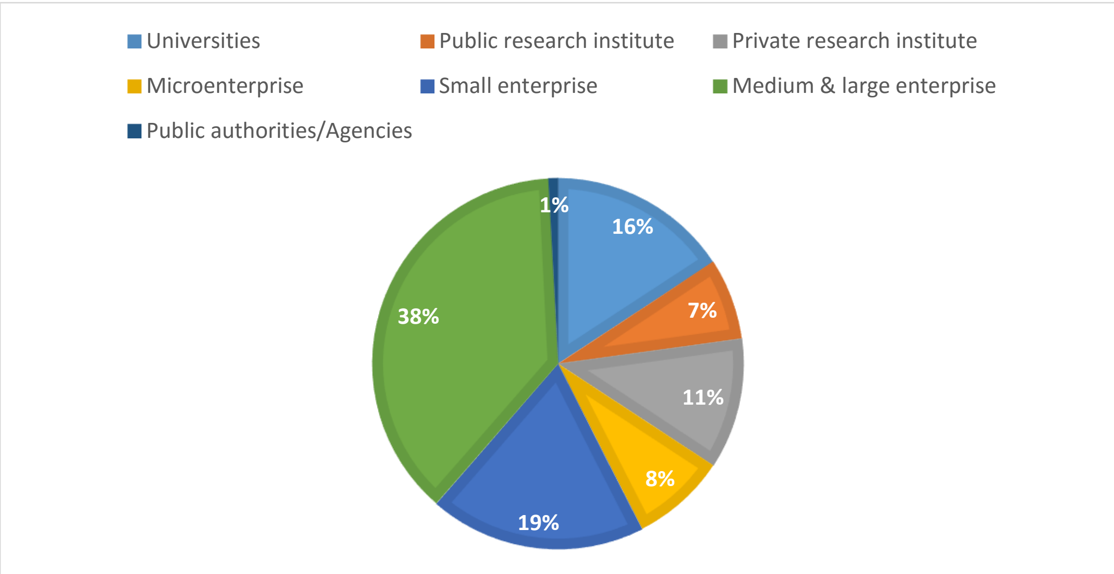
Based on the empirical research results obtained from the survey, this chapter's first goal is to characterize the Brazilian institutions that participate in national calls and do or do not intend to submit proposals for Horizon 2020. The second goal is to identify barriers that hinder these institutions from participating or to find ways in which their participation in the European program could be improved. Finally, the last goal is to identify aspects that could potentially strengthen the Brazilian participation in Horizon 2020. This would be done through analyzing the answers obtained from the survey with regards to what the Brazilian institutions believe are the most important aspects and gains of international cooperation.

[21] The mentioned survey was developed within the INCOBRA (Increasing International Science, Technology and Innovation Cooperation between Brazil and the European Union) project

5.1 Analysis of the results and characterization of the ST&I Brazilian institutions

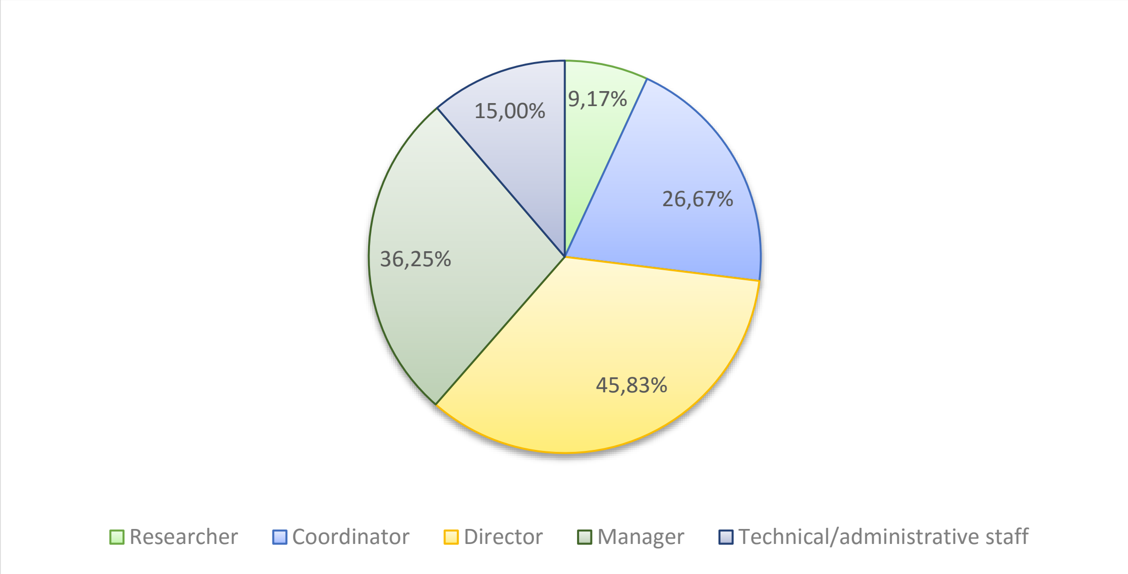
The survey reached 481 Brazilian institutions that had participated in some sort of national call for ST&I between 2007 and 2016. The participants who answered the survey were unequally distinct regarding the organization type. When examining Chart 19, a frequency distribution of all organizations that participated in this research can be seen. Of all Brazilian institutions surveyed, 38% were medium & large enterprises, 19% were small enterprises, 16% were universities, followed by private research institutes (11%), microenterprises (8%), public research institutes (7%) and public authorities and agencies (1%). Due to the lack of data obtained from "public authorities and agencies" (only 1% of the whole sample), the cross analysis relating this data and the variable *organization* will ignore this category when conducting the analysis.

Chart 19. Brazilian institutions per type of organization.



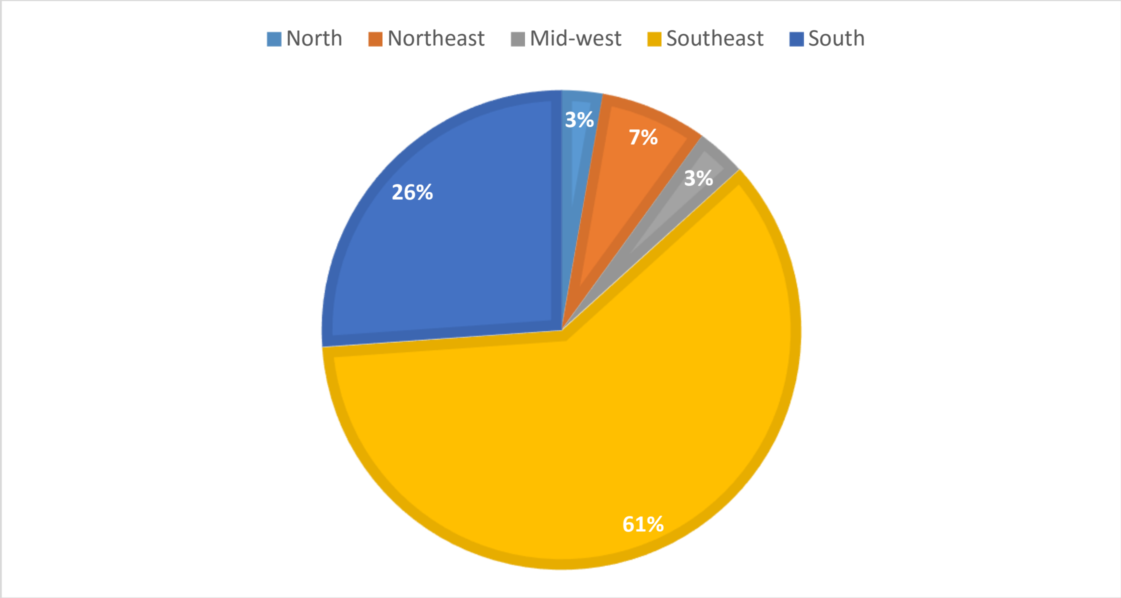
When taking a closer look at specifically who in these organizations answered the survey, it was concluded that they were mostly directors (45,83%), followed by managers (36,25%), coordinators of research projects (26,67%), technical and administrative staff (15%) and researchers (9,17%), as depicted by Chart 20. This unequal participation is due to the fact that the majority of the data was sent by enterprises, which sums 67,9% of the total answers, as previously stated.

Chart 20. Role of the survey participant in the organization.



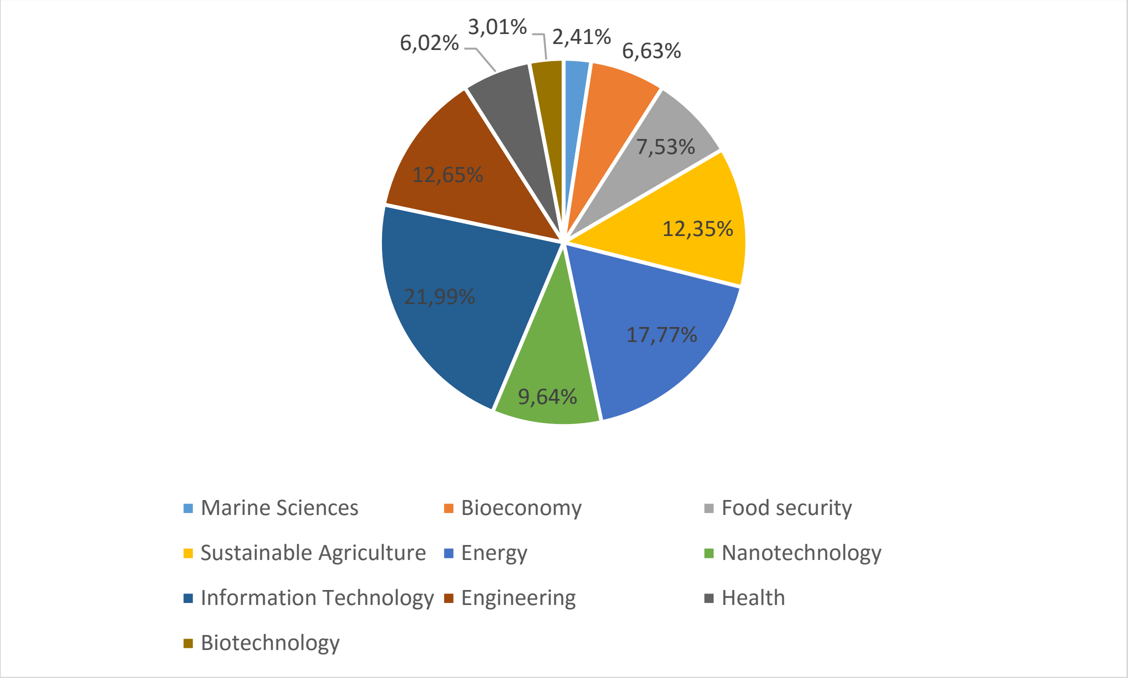
Of the institutions that answered the survey, most were geographically located in southeast Brazil, 61%, followed by the south, northeast, midwest and north. Chart 21 clearly illustrates the concentration of ST&I in the southeastern and southern regions of Brazil, as previously indicated by B.BICE (2015). This phenomenon could be explained by the industrial concentration being in the Southeast as well. Within these regions specifically, 32,24% of the institutions are located in São Paulo, 16,94% in Rio de Janeiro, 9,29% in Santa Catarina, 8,74% in Rio Grande do Sul, 7,65% in Paraná and 7,65% in Minas Gerais. Again, one would expect a higher concentration in these cities as São Paulo and Rio de Janeiro are considered major economic hubs within the southeast region. When looking at the southern region, participants are, for the most part, equally distributed within the three States (Paraná, Santa Catarina and Rio Grande do Sul).

Chart 21. Brazilian institutions per region



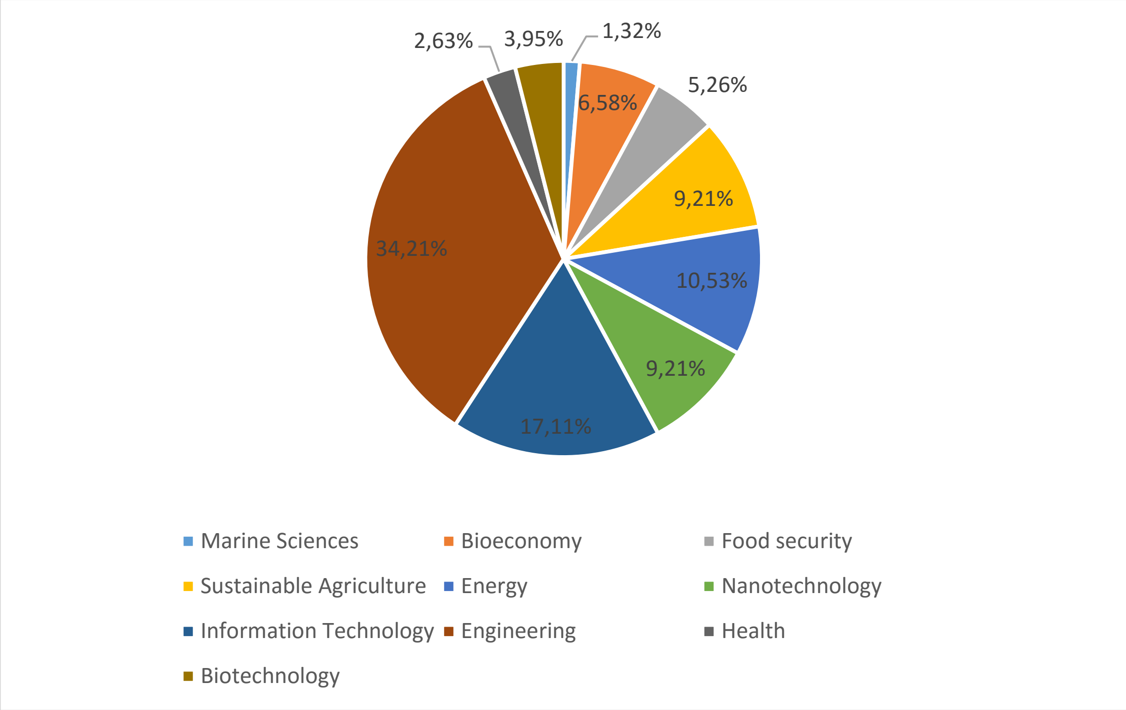
Other than concentrated in the southeast, the institutions that took part of the survey have a different frequency distribution when comparing the sample obtained by the survey to that of the research conducted by B.BICE (2015), which is exposed in the last chapter. The organizations in the area of health are underrepresented with 6% of the total participants, against 13% according to B.BICE (2015), as illustrated by Chart 18. Food security is underrepresented as well with 7,5% against 9%. Bio economy has a participation rate of 6,63% in this survey, while the participation, according to B.BICE (2015), is 9%. Engineering & space are two groups set together in the survey and have 12,65%, while in the B.BICE (2015), engineering & space together sum to 18%. On the other hand, information technology is overrepresented with 21,9%, against 4%, and nanotechnology with 9,64%, against 4%. Nevertheless, the frequency distribution points to the leading position of information technology organizations (21,9%), followed by energy (17,7%), engineering (12,65%), sustainable agriculture (12,35%), nanotechnology (9,64%), food security (7,53%), bio economy (6,63%), health (6,02%), biotechnology (3%) and marine sciences (2,41%), according to Chart 22.

Chart 22. Institutions that participated in the survey per scientific field.



When examining the institutions who have only ever submitted a proposal under FP7 or H2020, the majority are from a specific scientific field, according to Chart 23. The institutions under engineering are any engineering fields that do not comprehend the other areas contained in the same chart. The top scientific fields in this survey were: Engineering (34,21%), information technology (17,11%), energy (10,53%), nanotechnology (9,21%), sustainable agriculture (9,21%) and bio economy (6,58%). Marine sciences, biotechnology, food security and health are the least frequent scientific fields, even though they are considered priority fields both by the Brazilian national strategy for ST&I (MCTI, 2016) and the European Union (COM, 2012b; COM, 2012a).

Chart 23. Participation in EU programs per scientific field.

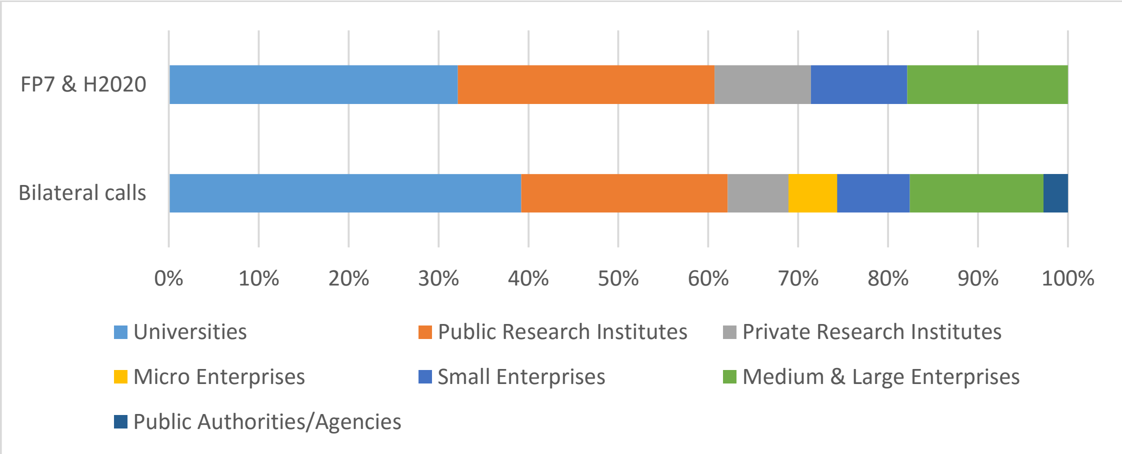


Upon examining all of the data received, 234 institutions answered the questionnaire completely and 247 only partially answered it. Of the 481 total answers, only 22,72% of these institutions have ever participated in any bilateral calls for ST&I with a European partner. Furthermore, an even lower portion, only 11,08%, of these institutions have already submitted a project under FP7 and Horizon 2020, ~~only 11,08%~~. Although such a small part of the sample has never submitted any proposal for ST&I international cooperation under the FP7 or Horizon 2020, a surprising 69,18% of the sample intend to submit a proposal under Horizon 2020. The reason for this are explored later in the results regarding the interests for ST&I international cooperation.

Among the institutions that have already submitted a project under bilateral calls and under FP7 or Horizon 2020, their distribution regarding the organization type is unequal. According to Chart 24, universities hold the highest share among the participants in both bilateral calls and FP7 or Horizon 2020, 39,19% and 32,14%, respectively. Public research institutes show the second highest participation level in both programs (22,97% and 28,57%), followed by medium & large enterprises (14,86% and 17,86%), small enterprises (8,11% and 10,71%), private research institutes (6,76% and 10,71%), microenterprises (5,41% and 0%) and public authorities and agencies (2,7% and 0%). Universities and microenterprises present a higher participation rate in bilateral calls for

ST&I with European Member countries than under FP7 and Horizon 2020, while public research institutes, private research institutes, small, medium & large enterprises present a higher participation rate in programs such as the FP7 and H2020.

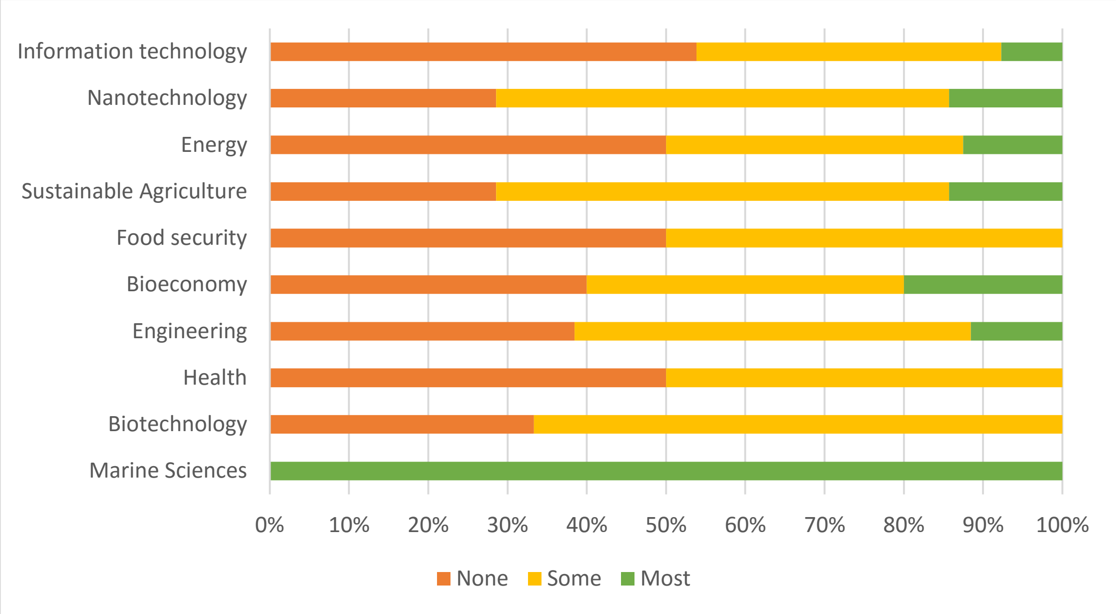
Chart 24. Participation of Brazilian institutions regarding type of organization.



Among those who submitted a proposal to FP7 and/or Horizon 2020, 40% had every proposal rejected, while 48% had some proposals accepted and 11,43% had most of their proposals accepted. Most surprisingly, among these three categories, the intention to submit a future project under Horizon 2020 grow to more than 90% each. Even those who had every single project rejected. However, when considering the scientific field, Chart 25 shows that information technology, energy, food security and health have the highest frequency of unsuccessful organizations – of which every project was rejected. These are at least half of the organizations in these scientific fields.

On the other hand, the organizations with a lower frequency of total rejections are found in the fields of nanotechnology, sustainable agriculture, biotechnology and marine sciences. The organizations under marine sciences have an expressive success under FP7 and H2020 as all organizations attested that most of their proposals were accepted. Nonetheless, it is important to state that these organizations are only 1,32% of the sample, therefore, represent only a small part of the sample. Furthermore, proposals submitted under bio economy have the highest organizations with a high success rate of 20%, followed by nanotechnology and sustainable agriculture with 15%. Engineering and energy follow with around 12% and 13% of organizations with a high success rate.

Chart 25. Submitted projects accepted per scientific field.



Regarding the level of information of the ST&I institutions, a surprisingly significant number stand out in Table 8. An incredible 56,3% of the institutions are absolutely not informed about FP7 and if considered together, the “not informed” group and the “poorly informed” group increase this number to 86,22%. This explains the low number of participation in FP7 or H2020. The numbers regarding the information level for H2020 are slightly lower (50,77%, when adding both “not informed” and “poorly informed” it totals 85%). However, these numbers are not statistically different from the information level for FP7[22], which means that there is strong statistical evidence that these institutions are as misinformed about FP7 as they are about H2020. Nonetheless, three institutions declared themselves “very informed” about Horizon 2020, while there was no institution that claimed to be “very informed” about FP7. This is an observation concerning exclusively the sample.

[22] The ANOVA test accepted the hypothesis that there is strong statistical evidence proving that the two means are equal and there is the same level of misinformation for FP7 as well as for Horizon 2020. See the ANOVA test in the annex.

Table 8. Participant's information level about FP7 and H2020.

	Universities	Public research institutes	Private Research Institutes	Micro Entreprises	Small Entreprises	Medium & Large Entreprises	Agencies	Total (%)
Informed about FP7								
Not informed	17	5	12	15	29	64	1	56,3
Slightly informed	17	7	12	5	12	22	1	29,92
Somewhat informed	4	5	3	1	5	9	0	10,63
Very informed	2	1	2	0	2	1	0	3,15
Extremely informed	0	0	0	0	0	0	0	0
Informed about H2020								
Not informed	12	4	15	14	21	61	1	50,39
Slightly informed	20	7	5	6	22	26	1	34,25
Somewhat informed	5	5	6	1	3	7	0	10,63
Very informed	3	1	3	0	1	1	0	3,54
Extremely informed	0	1	0	0	1	1	0	1,18

In absolute numbers, the micro, small, medium and large enterprises are by far the most affected by the lack of information. According to Chart 26, between 60% and 70% of them do not have information about FP7, while according to Chart 27, between 45% and 70% of them are not informed about Horizon 2020. Small enterprises presented a short decrease of misinformation from FP7 to H2020. From FP7 to H2020 some relative numbers change, however, there are no significant changes on the level of information regarding the organizations. This conclusion supports the previous data concerning the information level of Brazilian institutions in both programs. There is not a statistically significant change of information levels between both programs and the organizations. In other words, there is strong statistical evidence supporting that there is no difference of misinformation between FP7 and H2020.

Chart 26. Participant's information about FP7 per organization.

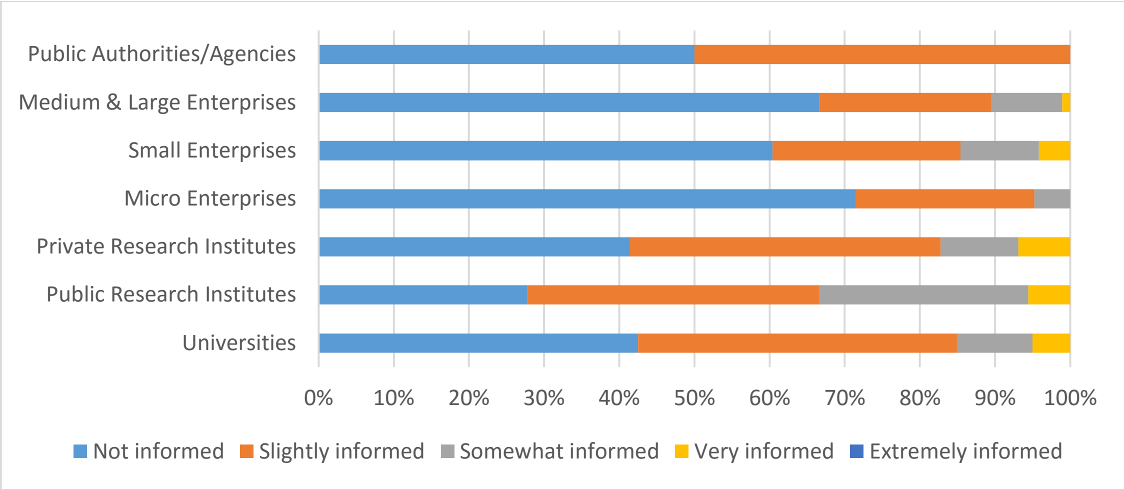
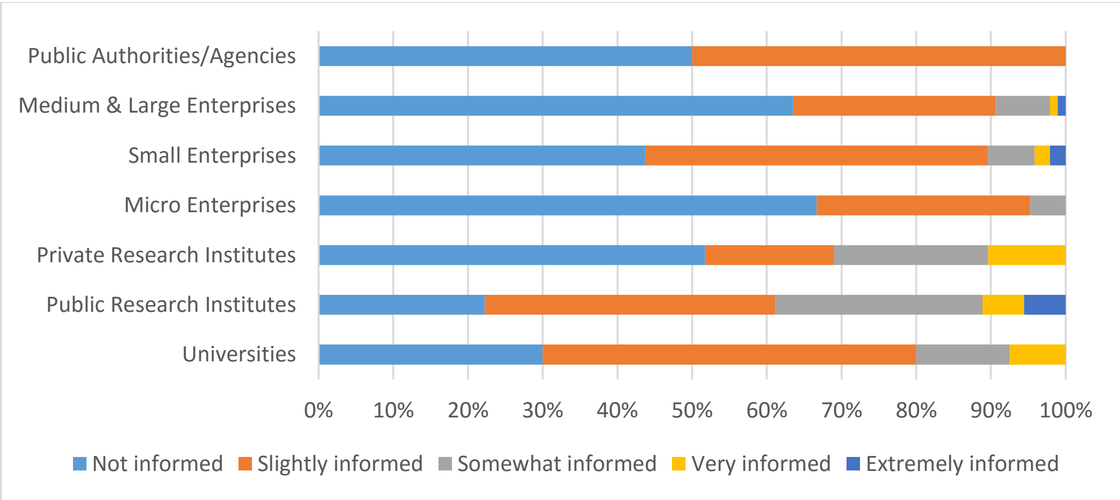


Chart 27. Participant's information about H2020 per organization.



The level of information about the European programs regarding the institutions that took part in the survey have slightly dropped, as illustrated in Chart 28 and Chart 29. Even though, as exposed previously, in aggregate there is no difference between the levels of misinformation of all participants, when disaggregating this data, the results slightly change. Organizations that work in the information technology area somewhat more informed about Horizon 2020 by around 10% advantage - considering a 10% drop in the "not informed" group in relation to FP7. Food security has a similar situation, with a 10% drop in the group "not informed" when asked about H2020. Finally, marine research is significantly better informed about H2020 than about FP7, with an almost 40% of these organizations stating to be very informed and somewhat informed, while the organizations that are not informed about H2020 are only around 12%.

Chart 28. Informed about FP7 per scientific field.

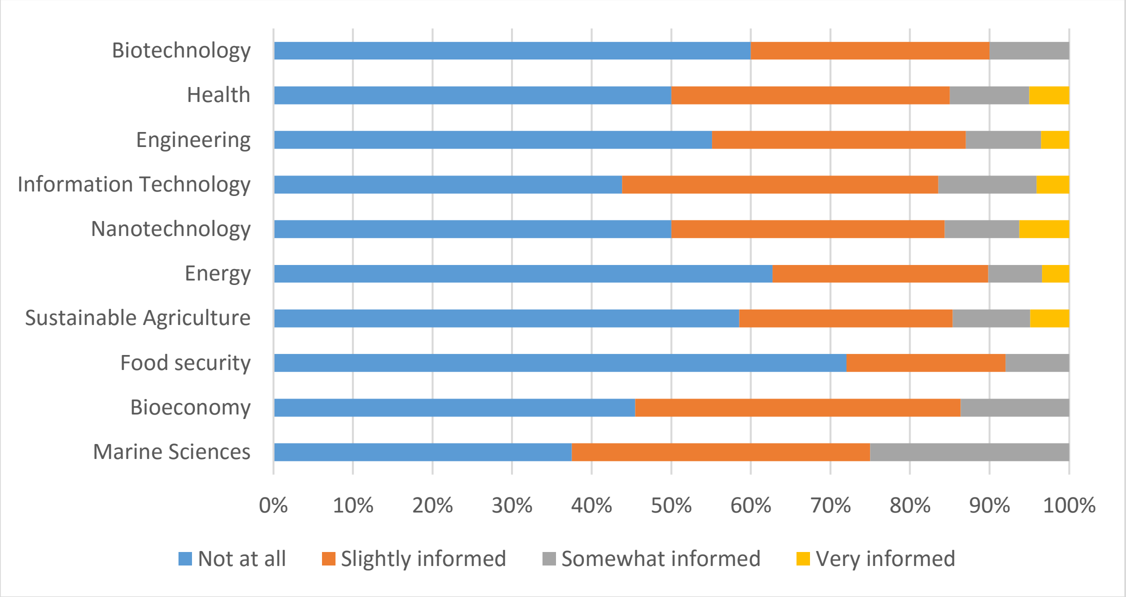
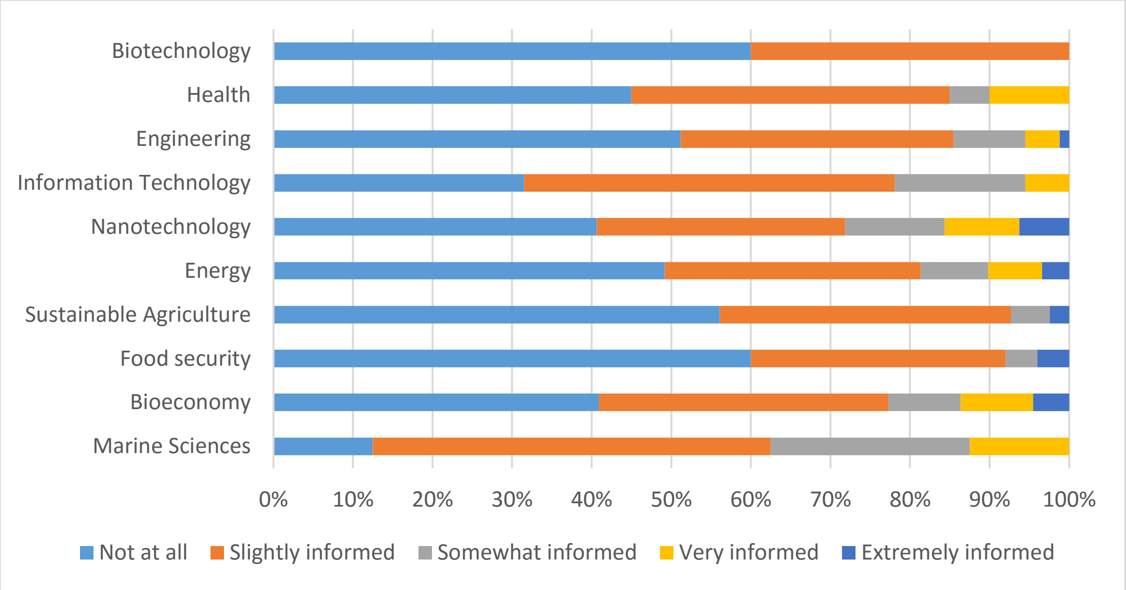


Chart 29. Informed about H2020 per scientific field.



5.2 Conclusions about the profile of Brazilian ST&I institutions

Based on the data there are a few considerations to be done. First, among those Brazilian institutions that participate in national calls for ST&I, only a few submitted a proposal for international cooperation projects with members of the European Union and even less have sent projects to FP7 and H2020. There is a very low participation of Brazilian ST&I institutions in projects with the European Union and European Members

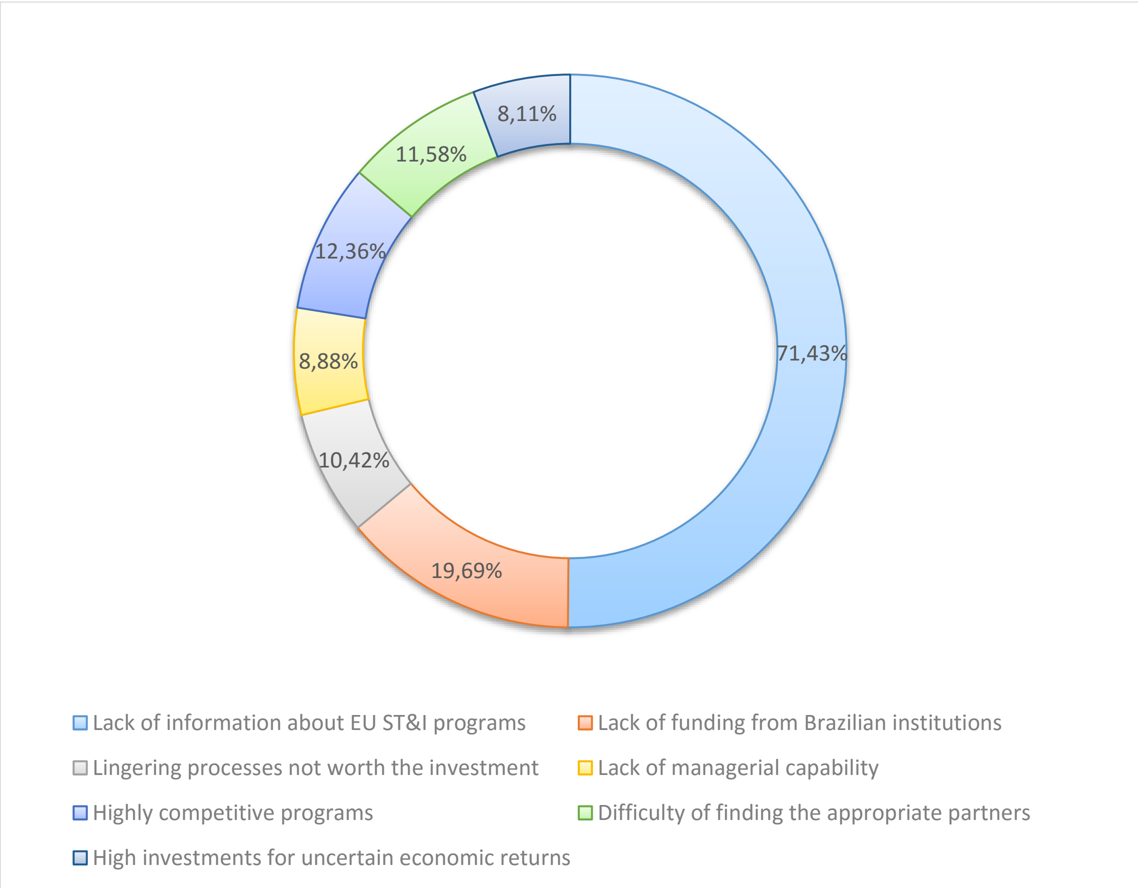
States. Second, most of the answers come from companies (micro, small, medium and large enterprises), which also reflect the third point, that most people who answered the survey have a role as director or manager, followed by coordinators of research projects. Fourth, the answers are mostly from ST&I institutions that are located in the Southeastern part of Brazil. They are highly concentrated in the southeast, specifically concentrated in São Paulo and Rio de Janeiro. Fifth, the organizations are highly concentrated in the scientific field of engineering, with 34,21%, followed by information technology, energy, nanotechnology, sustainable agriculture and bio economy. Surprisingly, the two fields of participants in H2020, which are considered priority fields do not appear as frequently. Besides IT, energy, food security and health present the highest rejection rate among all the scientific fields that submitted a proposal under FP7 or H2020. Sixth, universities and public research institutes are expressively the largest group that sent in proposals under FP7 and H2020. Seventh, there is a considerable lack of information of Brazilian ST&I institutions concerning the programs FP7 and H2020. There is strong evidence that the misinformation level remains equal from FP7 to H2020 and affects mostly the enterprises, while universities and public research institutes are relatively less affected by this lack of information.

5.3 Analysis of the barriers that have hindered the participation of Brazilian institutions in FP7 and H2020.

This subsection is going to highlight the greatest barriers that have hindered the participation of Brazilian ST&I institutions in FP7 and H2020. It will be based on detailed information obtained from the survey regarding reasons as to why 88,92% of the sample have never submitted any proposal under FP7 or H2020. The lack of information is an aspect that clearly can be a barrier to many Brazilian ST&I institutions. Lack of information is also an aspect that must be detailed. There is valuable information as to why these institutions that are "not at all informed", as well as why these institutions are "slightly informed" about FP7 and H2020. Furthermore, the survey deals with those institutions who sent a project and identified difficulties while preparing the proposals as well. Finally, this subsection is also taking into consideration those institutions who do not intend to send any projects to any European Program.

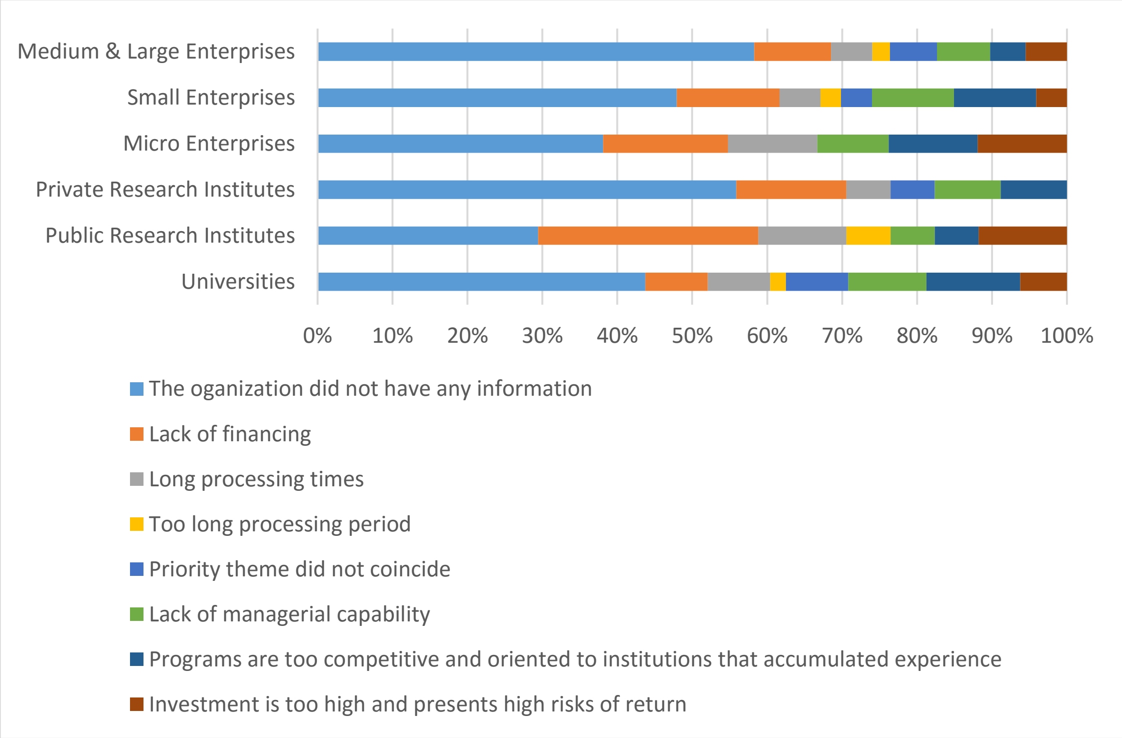
Initially, the institutions that never submitted any proposal under FP7 or Horizon 2020 were asked why they never submitted any project. Confirming the diagnosis from the previous subsection, Chart 30 shows that 71,43% of these institutions affirm that the organization had no information about the European Union's ST&I programs. Secondary aspects for not submitting a project were the lack of funding that could support the organization, with 19,69% and that the programs were highly competitive and favored the participation of those who already accumulated experience (12,36%). Furthermore, equally important aspects are the difficulty of finding the appropriate partners, as well as the fact that the programs are highly competitive, the investments are too high and the economic returns are uncertain, as the process of elaborating a proposal is too lingering and many organizations do not have the managerial capability for elaborating such proposals. Nonetheless, the lack of information is in fact the main factor that hinder the participation of Brazilian ST&I institutions in the European Union's ST&I Programs.

Chart 30. Reasons for not submitting any project under FP7 or H2020.



Concerning the frequency distributions disaggregated in organization, as illustrated in Chart 31, clearly the lack of information, again, represents a considerable reason for these institutions affecting mostly small, medium & large enterprises and private research institutes. Lack of funding represents a great concern for public research institutes when compared to other institutions. Besides, lack of funding is the second greatest concern of every other institution, except for universities. Universities identify a barrier in the high competitiveness of the programs, once it benefits those institutions that accumulate experience with European calls for ST&I. Furthermore, the high competitiveness of the programs strongly affects the micro enterprises because of their lack of experience in European ST&I programs.

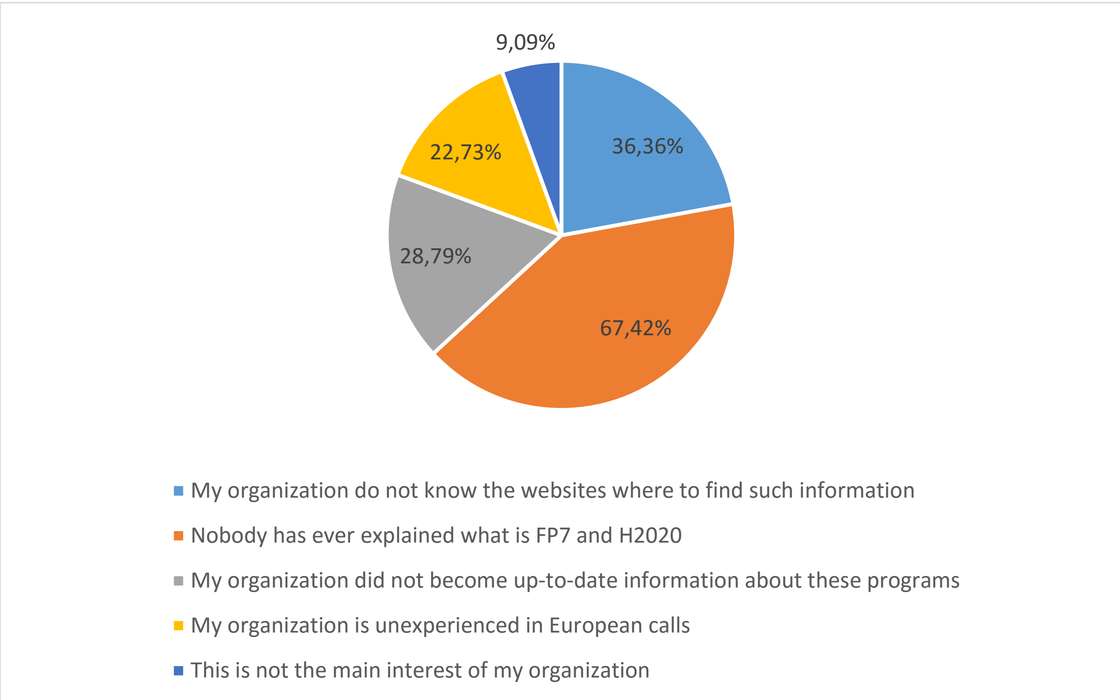
Chart 31. Reasons for not submitting any project under FP7 or H2020 per organization.



In addition, other aspects that have hindered the participation of Brazilian ST&I institutions in European programs were stated by organizations as well. One participant mentioned that Horizon 2020 would not finance projects implemented by Brazilian institutions, and subsequently hindered their participation in H2020. This might be explained by the exclusion of Brazil of the automatic funding in projects under H2020, as mentioned by B.BICE (2015). Currently, there is no official stance taken by the Brazilian government concerning whether or not any counterpart is to compensate the lack of funding from the European Union, through Horizon 2020. Furthermore, the language was pointed out to be another barrier, as well as the lack of institutional and financial support by FINEP to small enterprises. Finally, another barrier is the difficulty of having governmental support when the projects are not within the strategic areas set by the MCTI.

Nonetheless, the lack of information is clearly the main aspect that have hindered the participation of Brazilian ST&I institutions in programs of the European Union and the reasons for this lack of information must be explored. Of those surveyed, the majority responded that the lack of personal explanation about FP7 and H2020 was the main cause for not being informed. This case represents 67,42% of the answers, according to Chart 32, which points to the necessity of a more intensive focus on personal promotion of European ST&I programs in Brazil. This aspect is followed by the unawareness of the institutions of where to find such information in the internet (36,36%) and that the organization has never obtained up-to-date information about the programs (28,79%), with the same level of importance[23].

Chart 32. Reasons for lack of information about calls under Horizon 2020.

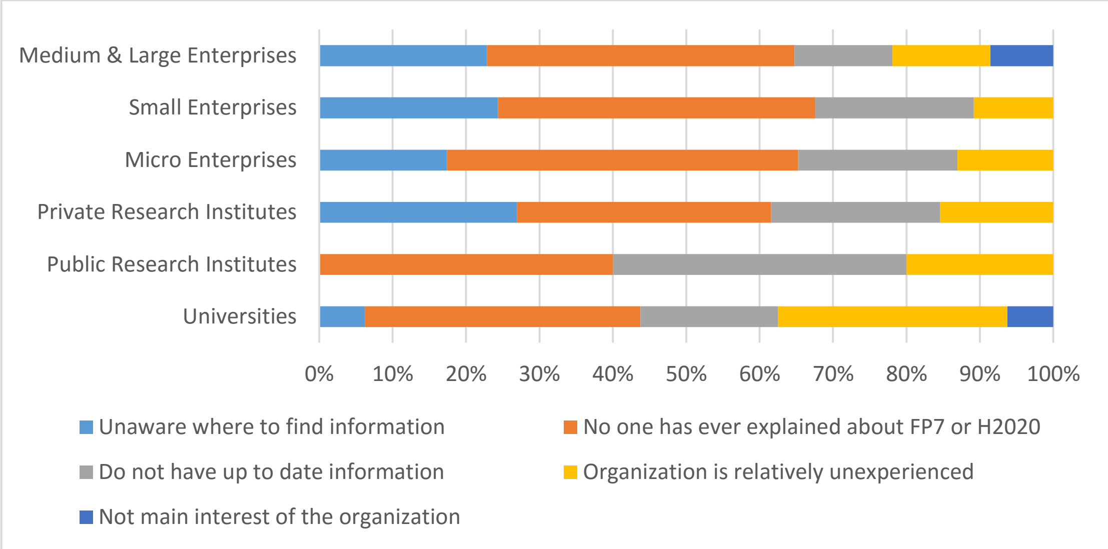


These previous observations, though, clearly affect all institutions somewhat in the same level, higher than 50% of the answers, except for public research institutions and universities. These two mentioned institutions are less affected with the lack of

[23] Statistically these two variables have the same mean with significance, according to the ANOVA test, also to be found in the annex.

knowledge of where to find information (0% for public research institutes and 6,25% in the case of universities), however, they are more affected by the lack of up-to-date information and the lack of experience with European ST&I projects, which represents more than 50% of the answers from those institutions.

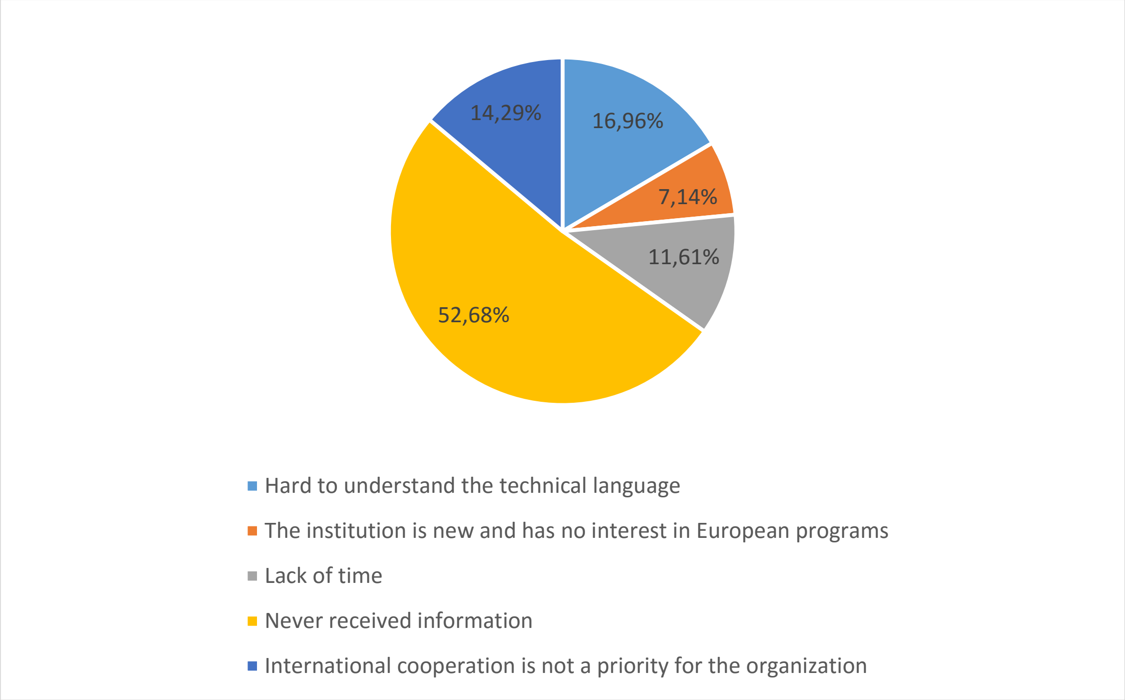
Chart 33. Reasons for the lack of information per organization.



Most institutions do not have any information about the European programs, nonetheless, some institutions are slightly informed. A third of the sample are organization that are slightly informed about FP7 or H2020. This means they have some information, but not enough to enable them to submit projects. The questions is why these organizations find basic information and do not inform themselves further.

Most of these organizations, 52,68%, said they never received any information about the programs, according to Chart 34. That is, they had basic information, but did not receive further information from the European Union about FP7 and H2020. Moreover, there are three other aspects that are important in understanding the lack of effort to inform themselves further about these programs. About 16,96% of the answers stated that although they received further information, the technical language used was a great obstacle in comprehending the European programs. Furthermore, 14,29% of the sample affirmed that international cooperation for ST&I is not the organization's priority, while 11,61% answered that the organization is focused in other responsibilities and does not have time to submit projects under FP7 and H2020.

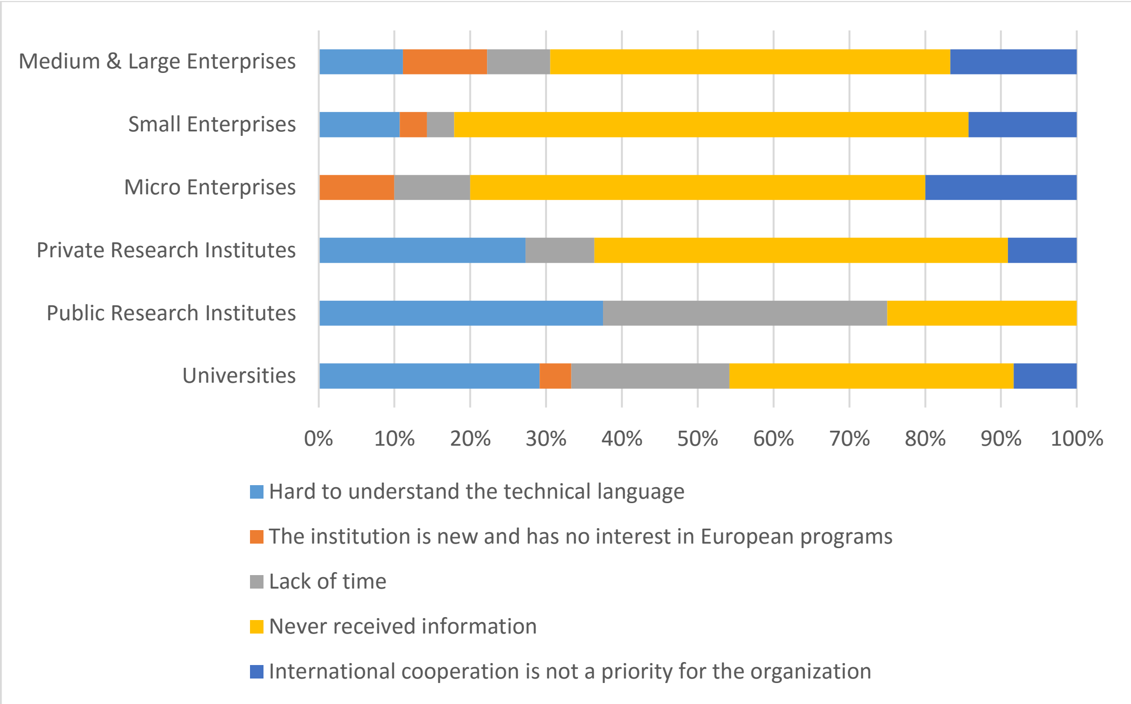
Chart 34. Reasons for being slightly informed.



While observing the reasons for being "slightly informed" when disaggregating the organizations, there is evidence that the private research institutes and the enterprises are "slightly informed" and continue being "slightly informed" for not receiving further information from the European Union, which represents a share equal to or higher than 60%, according to Chart 35. On the other hand, around 25% to 30% of universities and public research institutes respond with the same reason.

The difficulty of understanding the technical language, when receiving information about the European calls, is highest among research institutes and universities, but not relevant when considering enterprises. That is, even when research institutes and universities received further information, they could not understand the technical language used. In this sense, the European programs must work on simplifying the language and targeting those groups who are less informed about European calls for ST&I. Finally, the enterprises, however, are those who are less interested in calls for ST&I international cooperation, with shares that vary from 15 to 20%, while when concerning other organizations, the share is lower than 10%.

Chart 35. Reasons for being slightly informed per organization.



In section 5.1, it was mentioned that 40% of those institutions who have sent a project under FP7 or H2020, which were 11% of the total sample, had all of their projects rejected. The institutions that had all their projects rejected, pointed to three main reasons as to why their proposals were not approved: a) the assessment pointed to a lack of complementarity of the consortium; b) besides, the impacts of the projects were not accordingly considered and; c) there was lack of time to elaborate competitive proposals, because the consortium was established last minute.

Furthermore, some space was given for considerations, of which one explained that the project was funded by FINEP, it was evaluated as a high quality project and was presented to the committee. The explanation this organization received for their rejection was the lack of guarantee. A second comment about the matter was that the organization prioritized interdisciplinary projects with complementarity between the many scientific fields. However, the approved proposals were of different groups of disciplinary character working together and not necessarily complementing each other. This organization evaluated the committee as not respectful to the instructions set for the selections rules.

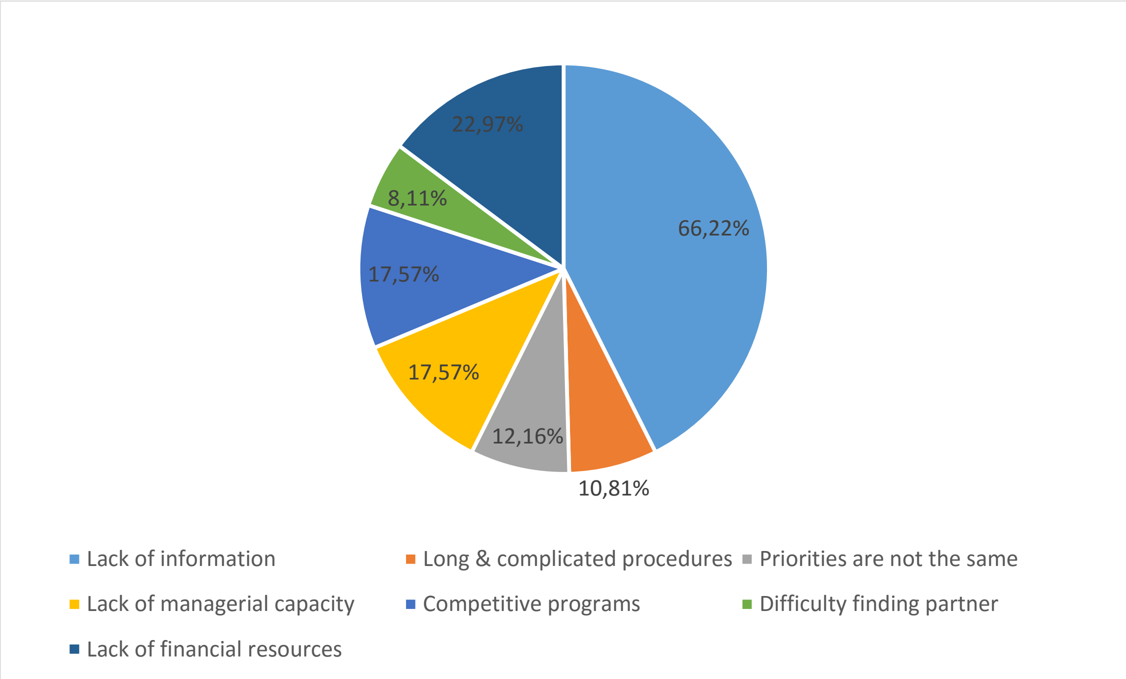
The same questions were set for those institutions that had some of their projects accepted. The reason as to why only some of the projects were accepted followed the same trend of those organizations that did not have any proposal accepted. Nevertheless, two reasons stand out: a) the committee pointed to the lack of complementarity of the consortium and b) the lack of time to prepare a competitive proposal, because the consortium was established last minute. These answers clearly state that the main difficulties for the organizations that intend to submit proposals is the task of establishing a consortium and elaborate a competitive proposal, due to lack of time or difficulty of finding the adequate partners to elaborate a project with complementarity.

Concerning further barriers that have hindered the participation in European programs, now the focus is on organizations that have submitted a proposal under FP7 or H2020, namely, the difficulties they identified while elaborating a project. Surprisingly, 48,28% of the participants believed the greatest difficulty was convincing their organization of taking part in the consortium, because a financial commitment was required, as illustrated by Chart 36. Again, the financial commitment is a barrier for organizations to participate in European calls, but surprisingly the lack of support from the institution was significantly pointed out. Besides, another barrier pointed out by 31,03% of the participants was the difficulty of finding an adequate partner to elaborate a proposal, followed by the long elaboration time of a competitive proposal, also 31,03%.

Chart 36. Difficulties while elaborating a proposal.

Finally, it remains open to analysis the group of institutions that do not intend to submit any proposal under Horizon 2020, which are 30,82% of the total sample. Chart 37 illustrates the strongest argument for not willing to participate in projects under H2020, pointed out by 66,22% of the answers, is the lack of information about the program – following the general trend of 50,58% of organizations that are not informed at all about H2020. This data strengthens the argument that the lack of information is the main barrier for the participation of Brazilian ST&I institutions in H2020. Secondly, the lack of capacity of Brazilian funding institutions to finance proposals was mentioned by 22,97% as a reason to demotivate the organization from submitting proposals. Further reasons for not wanting to submit any proposal were the high level of competitiveness of the programs and the fact that larger institutions who have experience with European programs were favored. This reason leads to the same amount of answers (17,57%) pointing to the lack of managerial capability to deal with European programs. Additionally, 12,16% of the answers stated that their field is not among the priority fields established for Horizon 2020.

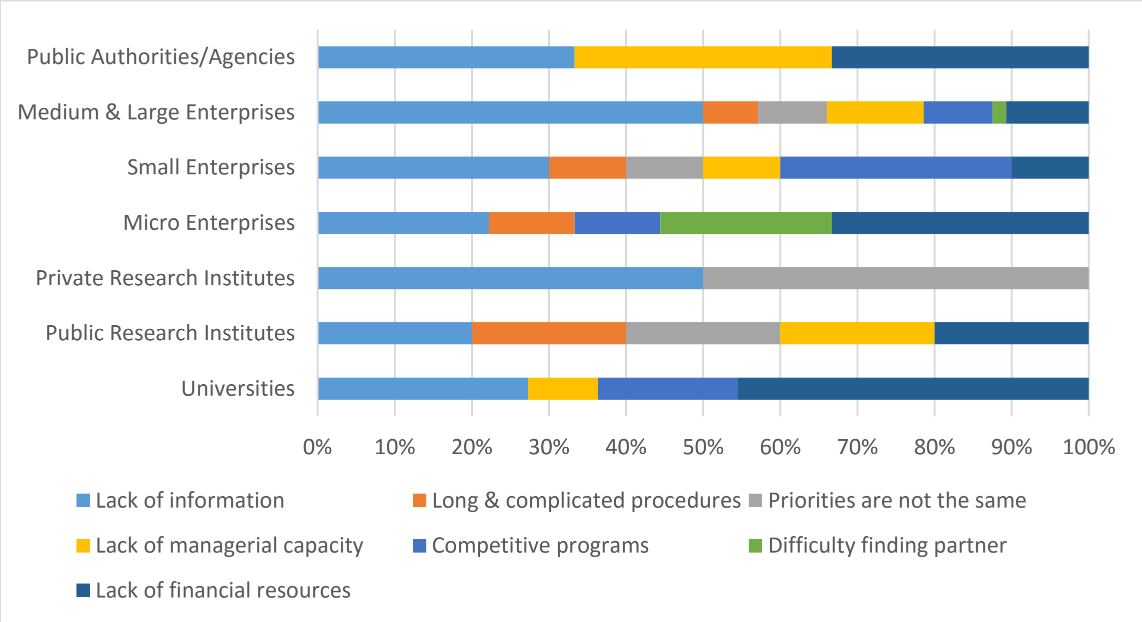
Chart 37. Reasons for not intending to submit a proposal under H2020.



When disaggregating these answers in organizations, Chart 38 shows that medium & large enterprises, as well as private research institutes, have their potential participation most affected by the lack of information (50%), while the private research institutes have also their scientific fields as a great barrier as they do not match with the priority fields established for Horizon 2020 (also 50%). Only some public research institutes suffer from the same cause, about 20%. The lack of financial resources clearly affects universities

(45%) and micro enterprises (around 33%) more drastically, while public research institutes are only 20% of the cases. On the other hand, small enterprises are most affected by the lack of information (30%) and the competitiveness of the programs (30%).

Chart 38. Reasons for not intending to submit a proposal under H2020 per organization.



5.4 Conclusions about the barriers that have hindered the participation of Brazilian ST&I institutions in FP7 and Horizon 2020.

Regarding the identified barriers, some main results can be quickly summarized. First, the lack of information among Brazilian ST&I institutions about FP7 and H2020 is confirmed to be the main barrier that have hindered the participation in Horizon 2020. Competitive programs and the difficulty of finding proper partners have significantly hindered participation as well. Second, the reasons for these barriers were the lack of personal explanation about the programs, the participants were unaware of where to find information and the difficulty of having access to up-to-date information. Third, the lack of information affects more significantly enterprises, while universities and research institutes are more affected by the lack of up-to-date information and the lack of experience in European calls. Fifth, to explain the low level of information, the participants mention that the European Union did not further inform about the European programs and when some participants did receive further information, the greatest difficulty was to understand the technical language. Universities and research institutes mostly receive further information, but are the ones to be more affected by the complicated technical language. Sixth, institutions that had all and some of their proposals rejected pointed to the lack of complementation of the consortium, as well as that the impacts were not properly considered and the lack of time to elaborate the proposal as the greatest barriers to have a greater success in FP7 and H2020. The lack of time to elaborate competitive proposals was pointed out by all participants who submitted a proposal to be a hinderance. Seventh, to elaborate a competitive proposal, the participants had difficulty convincing the organization to support them with financial commitments, as well as finding proper partners and again pointed the lack of time necessary to elaborate a competitive proposal as very important. Eighth, among those who do not intend to submit a proposal, the lack of information, lack of national funding, the highly competitive programs and being part of a non-priority field were the greatest aspects that have hindered the participation of these actors. Universities and research institutes are more affected by the lack of financial resources and enterprises by the lack of information.

5.5 Analysis of the aspects that could potentially increase the participation of Brazilian ST&I institution in Horizon 2020.

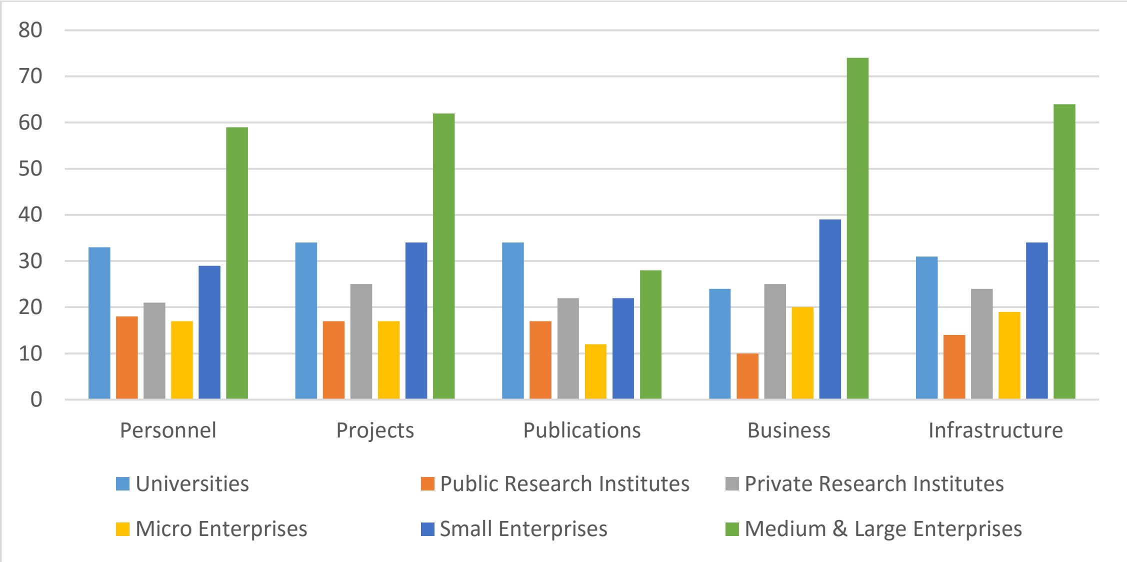
In the previous section, the barriers that have hindered the participation of Brazilian ST&I institutions were explored and analyzed. In the present section, the focus is going to be on the aspects that could potentially increase the participation of these institutions in Horizon 2020. Rather than looking exclusively at aspects that created difficult situations and hindered the participation of some organizations, the focus now lies on aspects pointed out by the survey that could enhance the participation, or create further incentive, of Brazilian ST&I institutions under Horizon 2020.

First of all, the organizations, as illustrated in Chart 39, were asked to rank the level of importance the organization gives to four features when cooperating internationally: personnel, collaborative projects, publications, business and infrastructure. Not surprisingly, business has the greatest frequency among all answers. Indeed, most of the organizations taking part in the survey are enterprises and in absolute numbers, this interest should prevails over the others. In total 64,54% of the 251 organizations have pointed this aspect as very important. This result is followed by the importance of collaborative projects, which had 146 answers and represents 57,48% of total answers, then by infrastructure and equipment which was very relevant to 55,56%, personnel, with 49,61% and publications with 40,73%. For the same reasons pointed above, publications is not surprisingly low on the scale of importance when setting an international cooperation, as the absolute numbers draw hasty conclusions.

It is very important to disaggregate the data in the diverse organizations in order to draw precise conclusions. For instance, it is graphically clear that the high frequency of answers regarding business as the most important aspect of international cooperation carries the responsibility of small, medium & large enterprises, which contributed to most part of these answers. It does not mean, that universities and research institutes do not see the same importance in business as an important aspect about ST&I international cooperation. It rather expresses that they do not have the inclination to prefer business on the same level that enterprises do. Unlike the enterprises, public research institutes are the type of organizations that tend to set a low priority when it comes to business. Another important comment is that, while giving a lot of emphasis on business, enterprises tend to give almost no importance to publications as an important result of international cooperation. A further comment that can be made from Chart 39 is that, despite the previously mentioned trends among different organizations, in general, there is no aspect that stands out and becomes more important than the others.

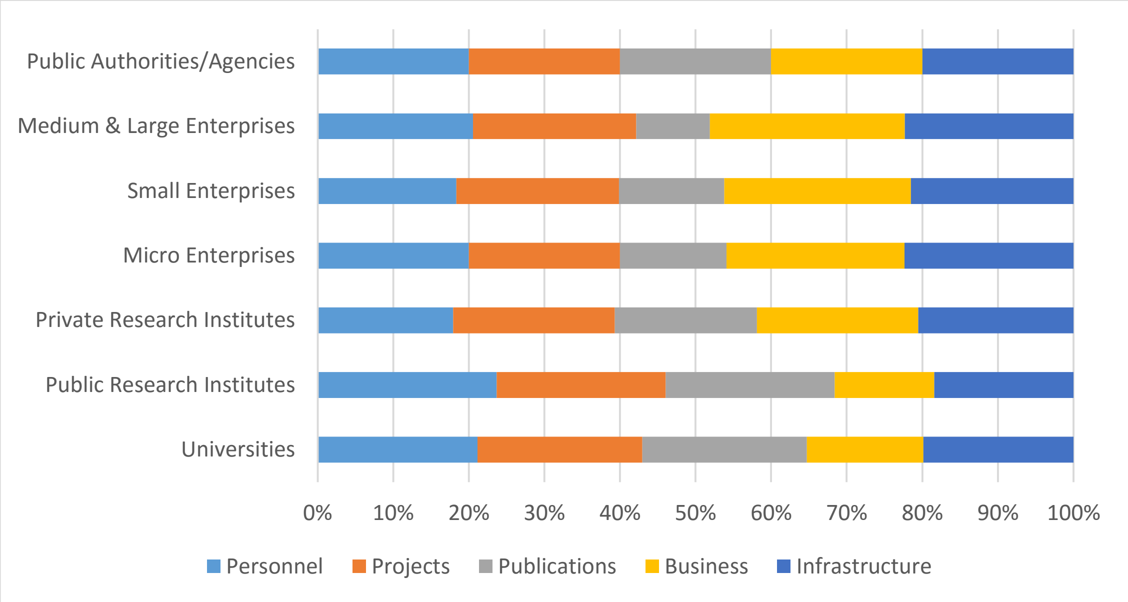
Unlike the illustration from Chart 40, when observing the same results in relative terms among different types of organizations, another features stand out. Chart 40 shows the frequency results in relative numbers, instead of absolute. Clearly, it is a different picture. From this perspective, different organizations do not differ regarding the given importance to “personnel”. Every organization gives roughly a 20% importance rating when it comes to personnel as the most important aspect of international cooperation. Therefore, enterprises recognize that the international training of personnel, as well as universities, contributes to the improvement of absorption capabilities that the personnel bring to the environment they work at and is a cumulative and important aspect for development.

Chart 39. Importance of selected aspects in international cooperation per organization type.



The importance of collaborative projects and infrastructure & equipment are homogeneous throughout the diverse types of organization, each carrying an importance of 20%. Obviously, enterprises benefit as well from complex and large infrastructures and as this is a high investment, it is always important to share costs – this might be a reason as to why international cooperation can come as a benefit for building research infrastructure and equipment. What in fact differs among the organization types are the importance given to publications and business. As already argued before, this difference takes place when comparing enterprises and research institutes. For instance, enterprises see business as the most important aspect of international cooperation and do not care about publications (particularly medium & large enterprises, for which the frequency of answers is lower than 10%). Universities and research institutes show to have the opposite trend. Business is not their greatest importance, but rather publications are their top priority – even though among universities all aspects have relatively the same level of importance.

Chart 40. Importance aspects of international cooperation per organization type, in relative terms.



Furthermore, other than lack of information, financing opportunities was detected as an important aspect that hindered the participation in FP7 and H2020. In fact, this aspect stood out again in the survey. The participants were asked which funding opportunity was of greatest interest for the organization. Surprisingly, among all 248 institutions that were asked this question, 89,11% answered that the interests were higher when funding came from calls from the Brazilian State for ST&I. Unlike the high interest given to national public funding, the other funding opportunities remained homogeneous. In fact, funding from bilateral calls with European countries are interesting to 69,08% of the Brazilian ST&I institutions. Horizon 2020 is interesting to 67,87% and international calls worldwide interests 65,86%.

Taking a quick look at Chart 41, the stochastic variables are again the medium & large enterprises. While every other organization has relatively the same interests for the four diverse funding opportunities, with a slightly but not significant preference for one over the other, medium & large enterprises have a significantly higher interest on national public funding than it has for every other funding opportunity. Therefore, organizations tend to present a relatively equal interest for the diverse funding opportunities, but medium & large enterprises, who tend to prefer national public funding to any other.

Chart 41. Interest on funding opportunities per organization type, in absolute numbers.

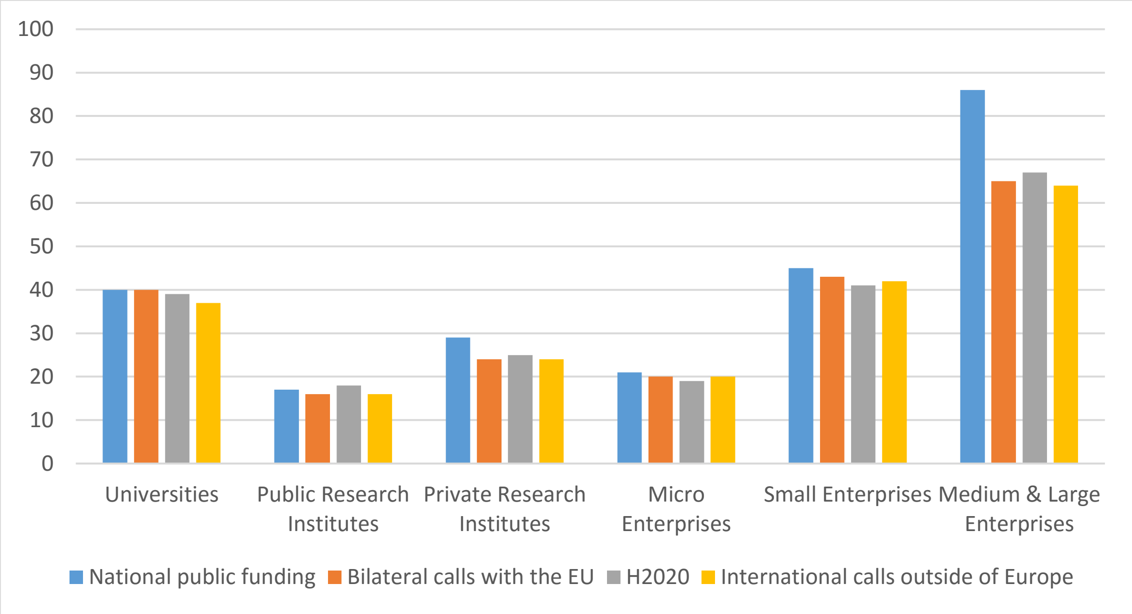
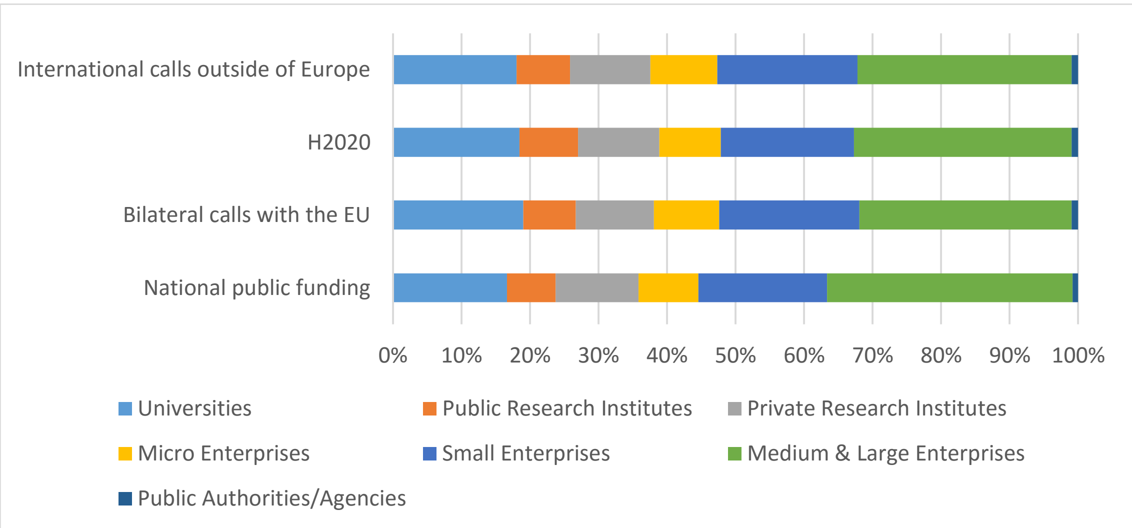


Chart 42 corroborates these arguments. There is a clear homogeneity of interests regarding different funding opportunities. Nevertheless, medium & large enterprises present a significant rise in interest from around 30% to 32% in the other funding opportunities, while in regards to national public funds, the interest rises to around 38%. Universities have homogeneous interests that consist of 17% to 19%, private research institutes have relatively constant interests around 10%, as well as micro enterprises, around 8%, small enterprises around 18% and public research institutes that have their interests between 6% and 8%.

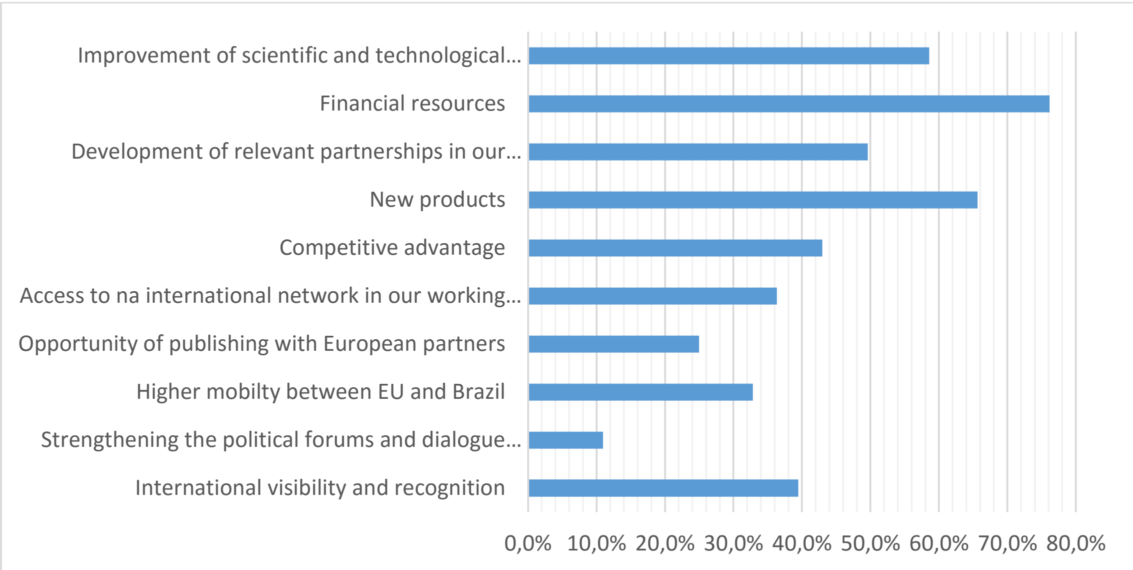
Chart 42. Interest on funding opportunities per organization type, in relative numbers.



Then, organizations were asked how the advantages of qualifying their personnel is important for them, or taking part in collaborative projects, or publishing, of doing business or building infrastructure. They have also been asked in which sort of funding they are most interested in. Furthermore, what are the most important results that can come out of an international cooperation, specifically, what would these organizations state are the most important results through a participation in Horizon 2020?

These organizations were further asked what they would classify as the most important result of participating in Horizon 2020. As seen in Chart 43, 76.17% stated that that access to financial resources is most important as it was by far the most frequently answered result. Subsequently, organizations chose the development of new products, 65,63%, the improvement of scientific and technological knowledge, 58,59%, establishing relevant partnerships in the working field, 49,61% and obtaining competitive advantage, with 42,97%.

Chart 43. Main goal if participating in Horizon 2020.

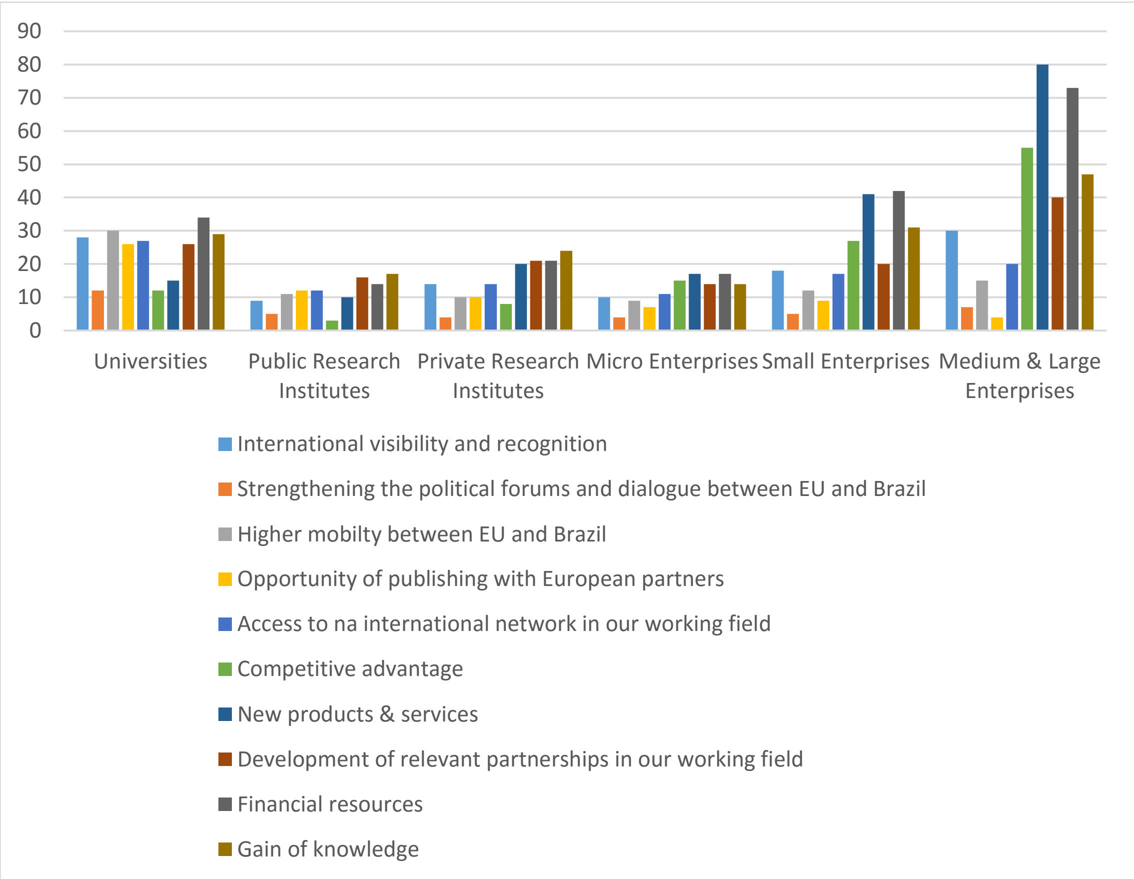


In addition, marketing was stated to be an extra feature of international visibility and an important result of international cooperation as well. Furthermore, new business opportunities with social and environmental impact were also cited as an important result that Horizon 2020 could bring as a benefit, while giving Brazilian ST&I access to foreign markets, partners and infrastructures. It was also mentioned that financial resources are, indeed, important, but are even more relevant when applied to the improvement of research infrastructures, buildings and equipment.

Moreover, Chart 44 clearly shows that universities have a lower interest in obtaining competitive advantage, new products and strengthening the political forums and dialogue between Brazil and the European Union - which is not important for most of the organizations, independent from the type. On the other hand, universities share a balanced interest regarding international visibility and recognition, higher mobility of personnel and the opportunity of publishing with the European partners (which in fact also comprehended as international visibility). Furthermore, they are also interested in accessing international networks, in developing relevant partnerships in the working area, especially interested in financial resources and finally in gaining knowledge.

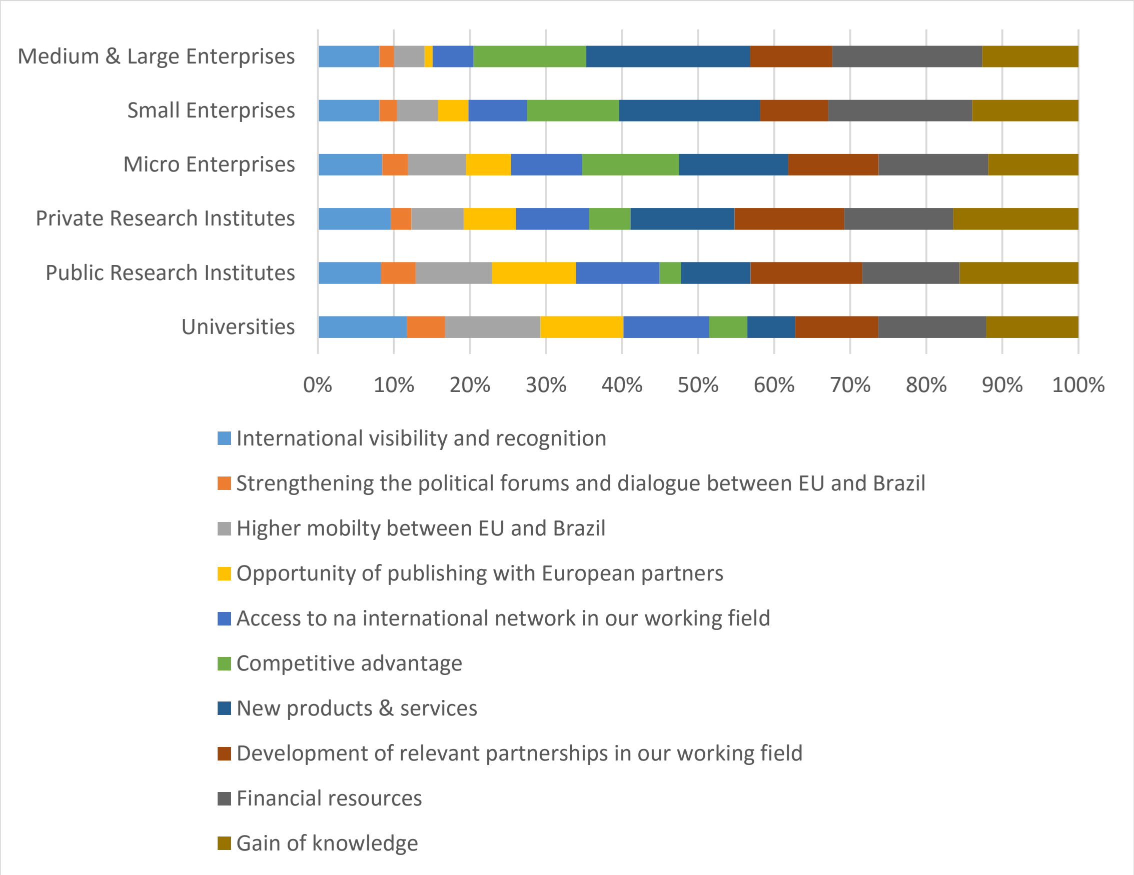
Research institutes in general are less interested in competitive advantage as a result from Horizon 2020, but have a balanced interest in the other aspects. However, when small, medium & large enterprises are concerned, the picture changes radically. Their focus is clearly in obtaining competitive advantage, financial resources, new products and gains of knowledge.

Chart 44. Main goal if participating in Horizon 2020 per organization, in absolute numbers.



It is important to mention again that when relative numbers are considered, the information that is abstracted from it also differs drastically. For instance, when analyzing Chart 45, universities express a slightly higher interest in international visibility and recognition. This trend also applies when considering the importance given to mobility of personnel between Brazil and the EU as well as the possibility of publishing with European partners. Nonetheless, an inverted relation shows the different priorities of firms, considering results from Horizon 2020. Enterprises are clearly more interested in obtaining competitive advantage, developing new products and, surprisingly, give slightly more importance to seeking more financial resources than research institutes.

Chart 45. Main goal if participating in Horizon 2020 per organization, in relative numbers.



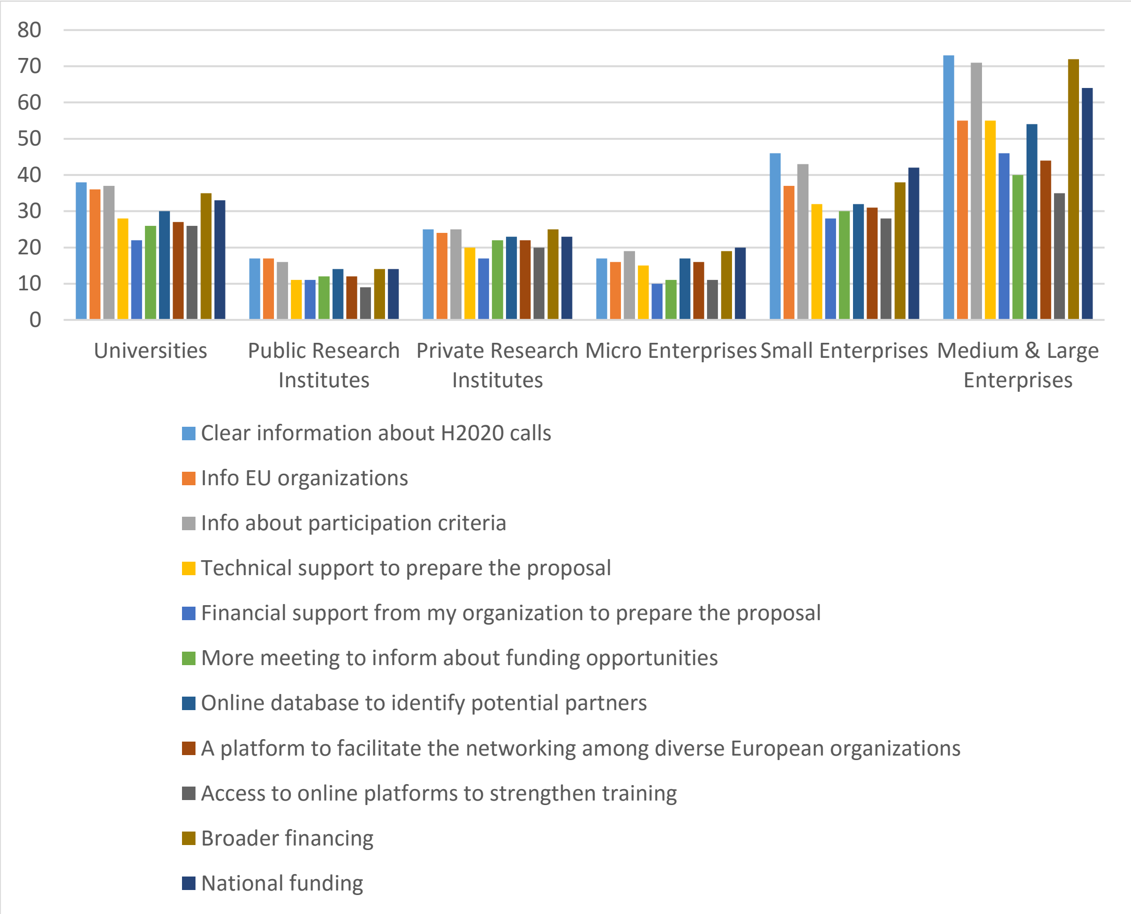
In addition to what aspect the institution would prioritize if participating in Horizon 2020, the survey also approached criteria that could potentially enhance the participation in the program. Confirming the previous conclusions to barriers hindering the participation of Brazilian ST&I institutions in Horizon 2020, the alternative to have clear and precise information about calls under Horizon 2020 is the most important criteria to enhance Brazilian participation, with 85,12%. In other words, an expressive amount of Brazilian organizations perceived the calls for Horizon 2020 as unclear and imprecise. Thereafter, these same organizations also perceived the criteria about the selection process of projects and for funding very unclear and imprecise. These organizations count for 82,16% of the answers.

Furthermore, very frequently identified criteria is for funding to be more far-reaching, including financial resources destined to pay research personnel, for example. This criteria is very important to 78,66% of the organizations. Financial support from Brazilian FAPs and agencies is also a criteria to be improved and contribute to an increase in Brazilian participation in H2020, according to the opinion of 76,99% of the organizations. Again, further information is an important criteria to improve the interest of Brazilian ST&I institutions in European institutions in regarding cooperation with Brazilian institutions (72,08%). There is a clear difficulty in finding the proper partners to cooperate elaborating a proposal to European programs – as already stated in the barriers to the participation in FP7 and H2020.

Less important when compared to the previous criteria, but equally relevant, is the lack of a database, where potential partners could be identified in a specific field – as pointed out by 66,53% of the participants as very important – as well as technical support to elaborate the proposals. Corroborating the results analyzed as barriers, lack of information plays the central role, followed by the funding opportunities, which plays a secondary role among the criteria, but is not to be ignored. That is, an increase of financial support from within the organization to projects of international cooperation was pointed out to be very important by 55,41% of the participants. More than half the participants think a more active financial support within the organization could potentially improve the Brazilian participation in Horizon 2020. The frequencies for all the different presented criteria are relatively high – even the criteria with least frequency of answers were above 50% – this means that all the criteria, in a less or higher degree are not efficient to guarantee the Brazilian participation in Horizon 2020.

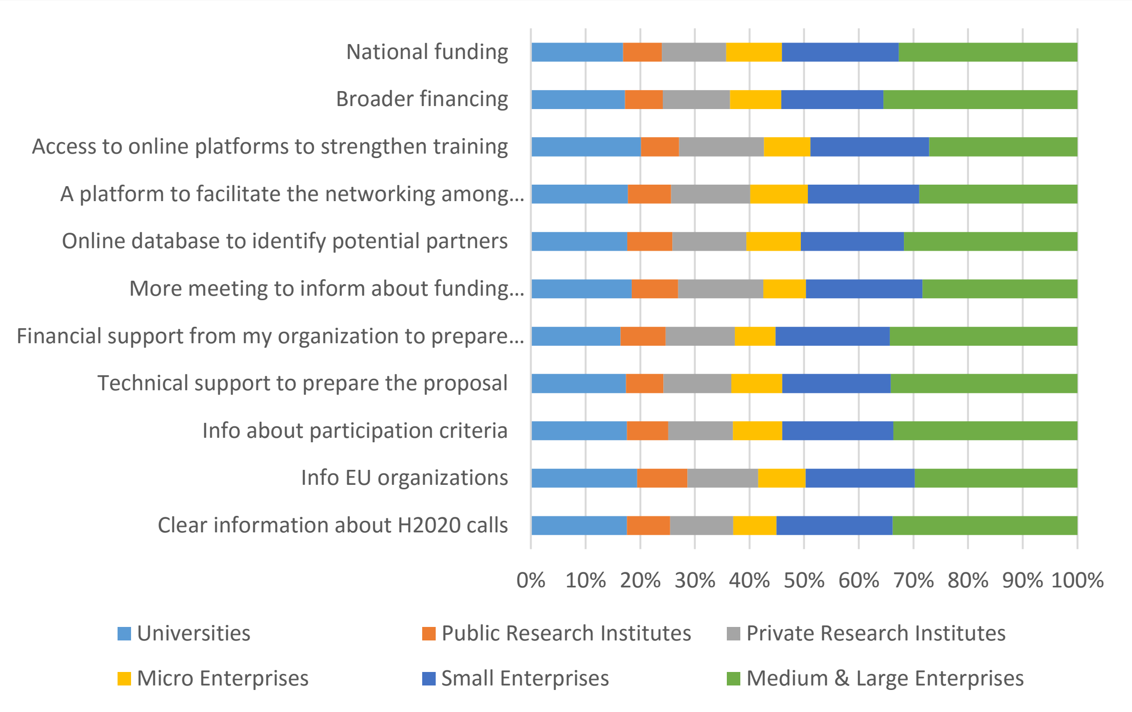
When disaggregating the data per type of organization, Chart 46 depicts a clear trend that shows the highest relevance of lack of information about the calls, potential partners and selection criteria, as well as a lack of broader funding and lack of sufficient national funding opportunities that could enhance the international cooperation within Brazilian ST&I institutions. This trend is more evident among universities and small, medium & large enterprises. Among these, medium & large enterprises are the most sensitive organizations to these criteria, which distort the absolute numbers regarding the confrontation of the importance – which do not confirm when seeing the relative numbers in Chart 47. On the other hand, research institutes and micro enterprises seem to be slightly following the general trend, but not so evidently as the other organizations.

Chart 46. Criteria that could potentially increase the Brazilian participation in Horizon 2020 per organization type, in absolute numbers.



Different from the considerations regarding the absolute numbers, the relative numbers give a different picture to the subject. According to Chart 47, there is no clear evidence of preference the organizations have for a specific criteria that could potentially increase their participation. Universities have the importance given to the different criteria varying from 16% to 20%, of which the two aspects with higher importance to universities are the lack of information about potential European partners and the lack of access to an online platform, where the capabilities of potential participants could be enhanced. This last criteria is one of the least relevant aspect for medium & large enterprises, who point out that a broader funding, the lack of precision and clearness of European calls, as well as its selection criteria are the criteria that could better enhance the Brazilian participation. Instead, the other organizations give relatively the same importance for all the criteria.

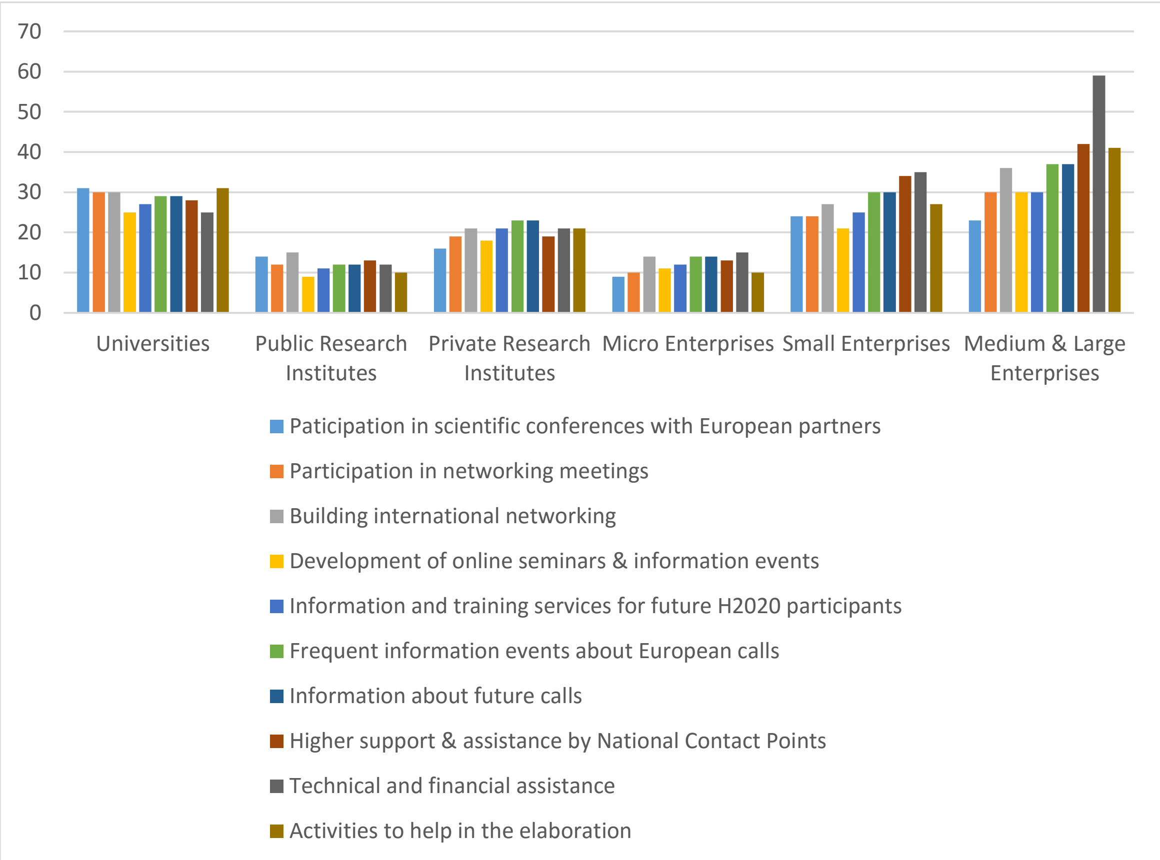
Chart 47. Criteria that could potentially increase the Brazilian participation in Horizon 2020 per organization type, in relative numbers.



When regarding the support activities that can improve the Brazilian participation in Horizon 2020, the most popular among the participants was the financial and technical assistance for innovation activities (such as orientation to strengthen business plans), with 67,1%, followed by the support & assistance given by National Contact Points in Brazil, 59,83%. Then, a network to facilitate the contact with the most relevant international partners, in order to share competences concerning the central interests of Brazil and the European Union (56,28%), as well as events that could help with information about Horizon 2020's future calls (56,09%) and activities to help with the elaboration of proposals and project implementation (54,94%). At the bottom of the list are the realization of online seminars to inform organizations about the H2020 program (45,18%) and the participation in scientific conferences with the European partners (44,59%).

Most organizations place relatively the same level of importance to the different support activities, except for small, medium & large enterprises, who tend to express a much clearer trend towards prioritizing financial and technical assistance, a higher support & assistance by the National Contact Points and the realization of activities that could help organizations to elaborate proposals, as illustrated in Chart 48. In adding to them, information does not lose relevance as an important support activity to potentially enhance Brazilian participation in H2020. Frequent informational events about future European calls under Horizon 2020 and informational & training events for successful projects are also among the most important aspects that could improve the Brazilian participation in H2020.

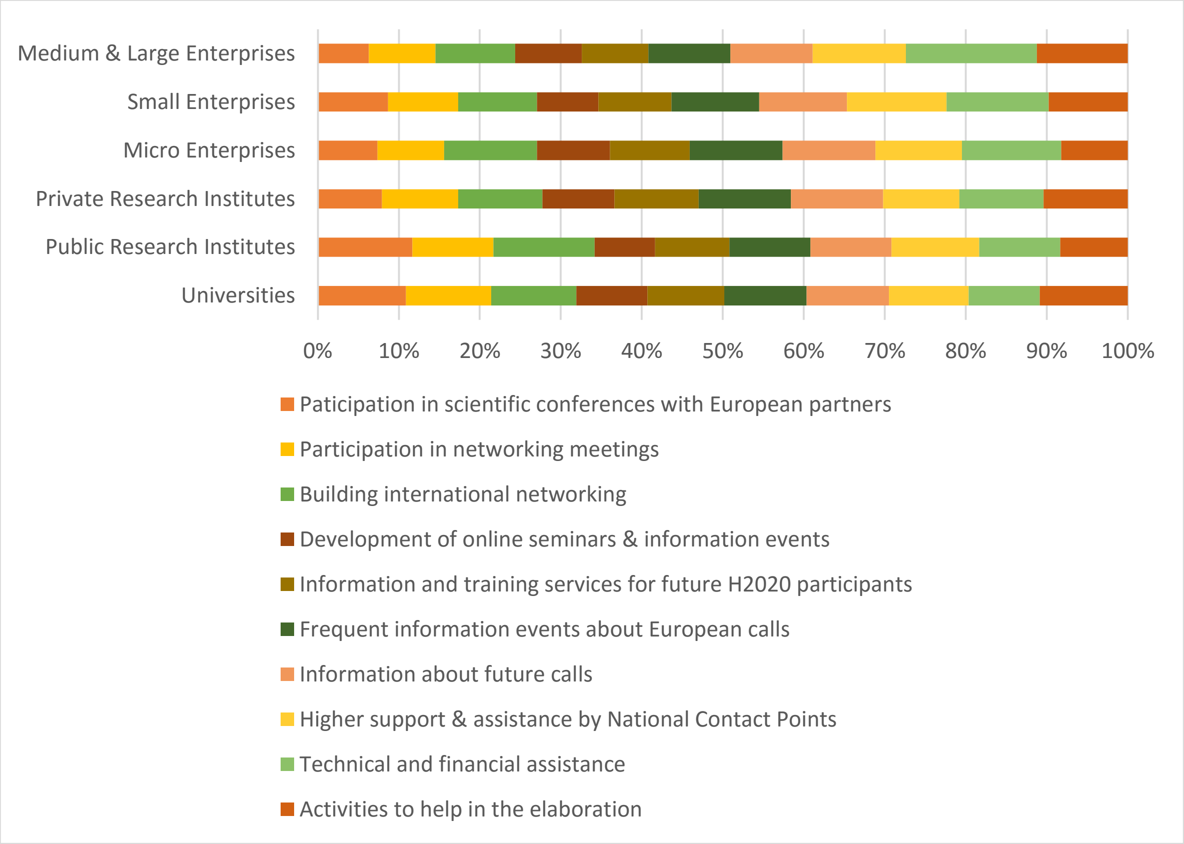
Chart 48. Importance of support activities to enhance the Brazilian participation in Horizon 2020, per organization, in absolute numbers.



Once again, these are absolute numbers and do not reflect the frequency distribution of the results regarding the sample analyzed per organization – which consists of a majority of enterprises. This explains the unpopularity of the participation in scientific conferences as an activity that could potentially improve the Brazilians participation in Horizon 2020. Therefore, R&I policies must be targeted to reach a certain type of institution, with regards to their own needs. Chart 49 shows that medium & large enterprises are less interested in participating in scientific conferences with European partners, but show a higher interest in technical & financial assistance, as already mentioned before. Small enterprises present a higher tendency to recognize the participation in scientific conferences as an important support aspect. The explanation might be in gaining international visibility, a crucial aspect mentioned as very important by the participants before.

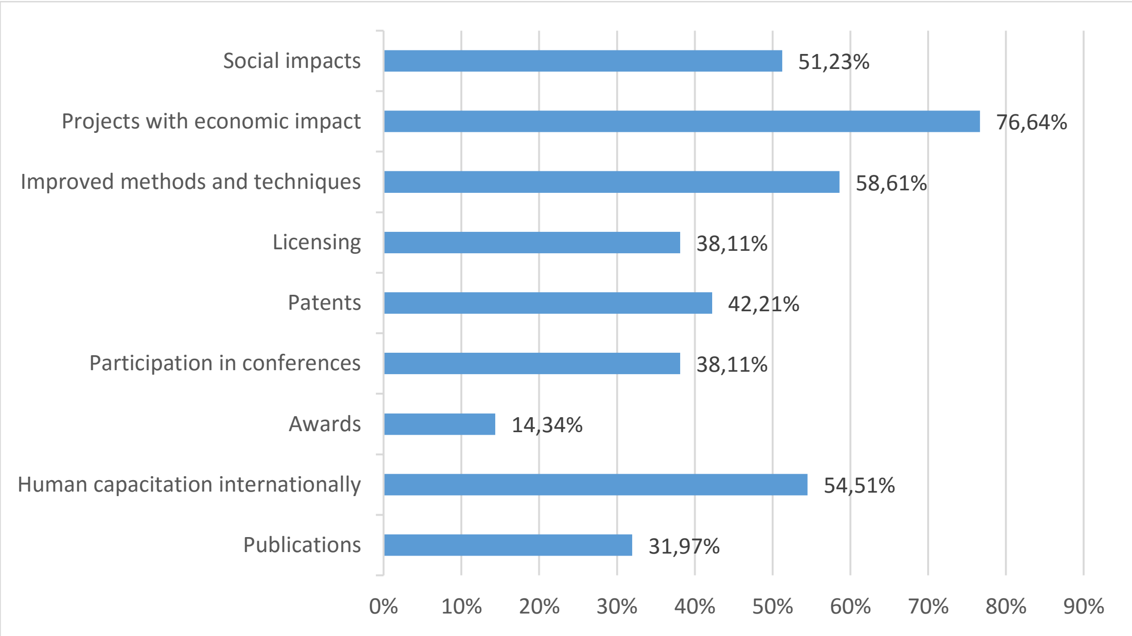
On the other hand, policies targeted to enhance the participation of universities in Horizon 2020 should have a greater emphasis on promoting the participation of these institutions at scientific conferences with European partners, as well as offering support activities to help elaborate proposals. Nevertheless, every support aspect has been pointed out with a significantly high frequency by all organizations, which tend to conclude as well that all the listed support activities are seen as important by Brazilian ST&I organizations and could potentially increase their participation in Horizon 2020.

Chart 49. Importance of support activities to enhance the Brazilian participation in Horizon 2020, per organization, in relative numbers.



Finally, the last aspect that could potentially increase the participation of Brazilian ST&I institutions in Horizon 2020 regards the personal gain that researchers, project coordinators, directors and managers see as an important motivation. The **most favorited** result that could potentially motivate **and increase** participation in H2020 is by far the development of projects with economic impact, **as stated** by 76,64% of the participants. Again, the clear preference of enterprises for projects with economic impact increases the frequency given to this answer.

Chart 50. Personal motivations for participating in Horizon 2020.

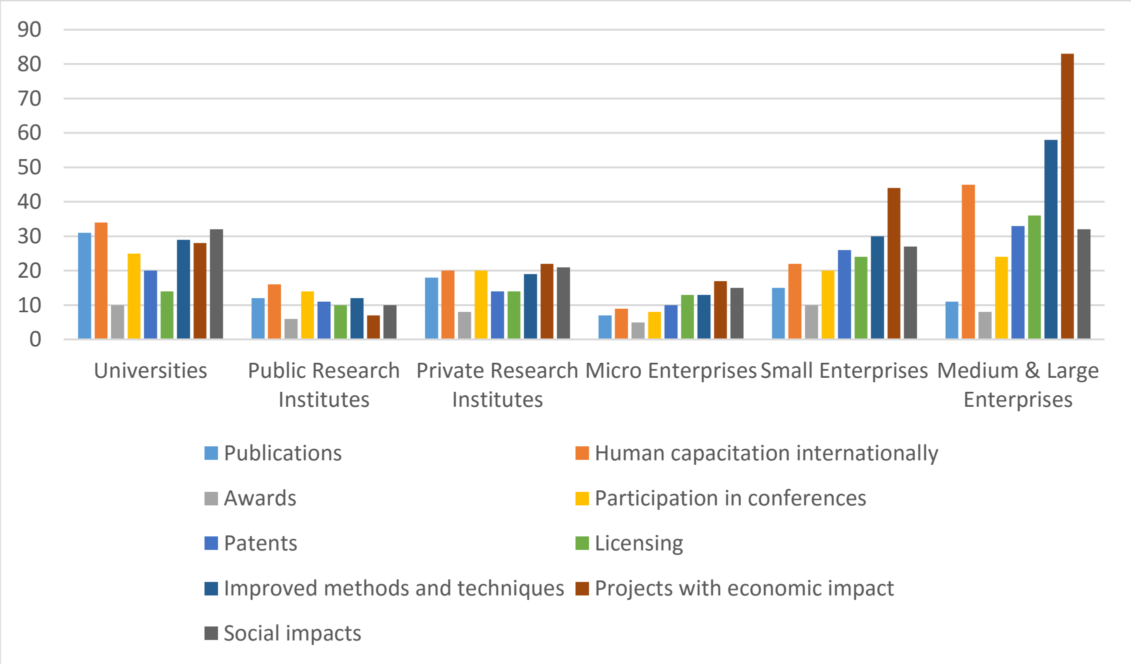


The second most frequented answer has 58,61% of the participants stating that improved methods and techniques is the second most important result that could personally motivate the participation in H2020. This aspect is followed by personnel trained internationally (54,51%) – showing that the development of human capital, and the value of tacit and cumulative knowledge, is recognized as important to improve the absorption capabilities of an organization. 51,23% of participants pointed out that projects with social and political impacts are equally as an important motivation, followed by patents (42,21%), licensing agreements (38,11%), participation in scientific conferences, seminars & workshops (38,11%), publications (31,97%) and awards (14,34%).

Again, after disaggregating the data, Chart 51 clearly shows that publication is indeed a very important aspect for universities and research institutes. Other than publications, personnel trained internationally, participation in conferences, seminars &

workshops, improved methods and techniques, projects with economic, social and political impacts are all very important motivations that could enhance the participation of universities and research institutes in Horizon 2020.

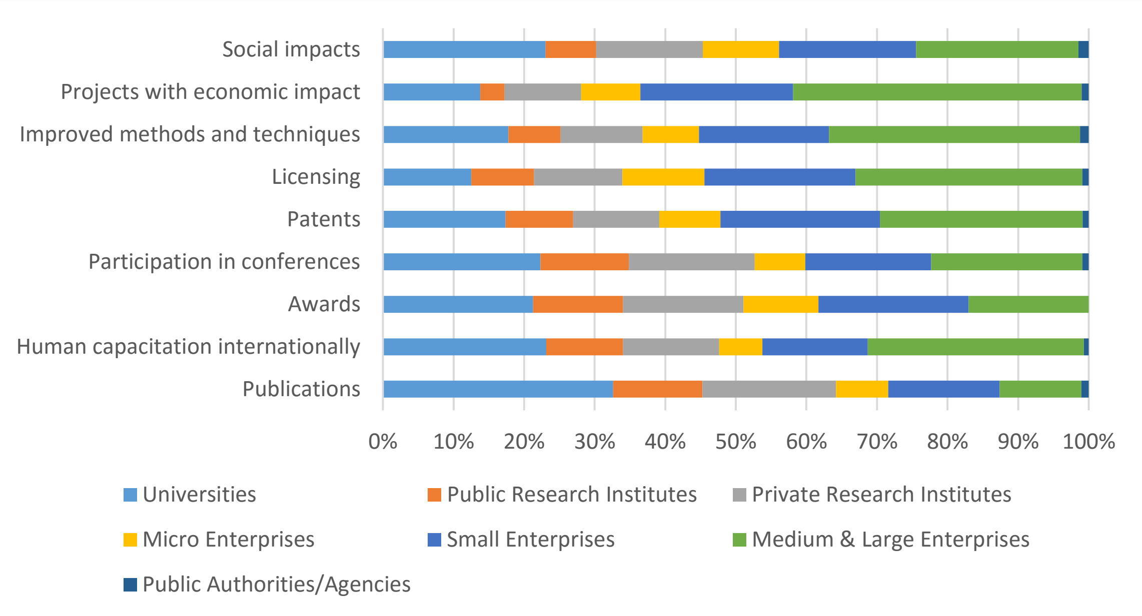
Chart 51. Personal motivations for participating in Horizon 2020, per organization, in absolute numbers.



On the other hand, enterprises' behavior follow the general results, which is a stressed importance on projects with economic impacts, improvement of methods & techniques and personnel trained internationally. In addition, licensing agreements and patenting is as well very important for these enterprises, as an instrument to protect the knowledge created in innovative processes and difficult the appropriability conditions of their competitors. Lastly, participants saw rewards as the least motivating aspect to increase their participation in Horizon 2020.

These considerations can be easily corroborated when considering Chart 52. The data considered in relative numbers leads to the same previous conclusions. Nevertheless, in this chart it becomes more clear the lack of importance public research institutions give to projects with economic impact, but do care about awards, publications, participation in conferences, capacitation of human resources, patents and licensing agreements. Private research institutes do give importance to economic results. However, they see publications, participation in conferences, awards, the capacitation of their human resources, and so on, as equally important. Small enterprises have similar priorities as private research institutes. The shift is on medium & large enterprises, who indeed see less relevance in publications, awards and participation in conferences. On the other hand, they however appreciate projects that have an economic impact, improved methods and techniques, licensing agreements, patenting, and the training of their personnel internationally.

Chart 52. Personal motivations for participating in Horizon 2020, per organization, in relative numbers.



Finally, public policies aiming to enhance the participation of Brazilian ST&I institutions in Horizon 2020 must direct their efforts targeting policies towards specific groups of organizations. This research identified that different types of organizations define barriers and motivations differently. In other words, efforts intending to enhance the Brazilian participation in European programs should be targeted to specific sectors, aiming to satisfy their specificities.

Die vorliegende Arbeit hat darüber hinaus identifiziert, dass unterschiedliche Arten von Organisationen Barrieren und Prioritäten unterschiedlich definieren. Daher sollte eine effektive öffentliche Politik gezielte Maßnahmen setzen, um die brasilianische Beteiligung in Horizont 2020 zu erhöhen und die Barriere einer Teilnhame für bestimmte Gruppen zu überwinden

5.6 Conclusions about the conditions, support activities and criteria that could potentially enhance the participation of Brazilian ST&I institutions in FP7 and Horizon 2020.

Rather than just identifying aspects that have hindered the participation of Brazilian ST&I institutions in FP7 and H2020, this subsection has identified and analyzed the aspects, support activities and criteria that, according to the whole sample, could enhance the Brazilian participation in Horizon 2020. First, the business aspect is the greatest interest of a potential Brazilian participation in H2020, followed by access to infrastructure & equipment personnel and publications. Business is more important to enterprises whereas publications are to universities, while all the other aspects are equally as important to every institution. Second, national funding is by far the preferred funding opportunity, even though it is outstanding only when regarding medium & large enterprises. Third, organizations stressed that their participation in Horizon 2020 would be enhanced by having easier access to financial resources, by far the most frequent answer, the development of new products, and the improvement of scientific and technological knowledge. Then, universities see international visibility, mobility, financial resources and gains of knowledge as the main goals in international cooperation, while medium & large enterprises focus on financial resources, competitive advantage and the development of new products & services. Fourth, in order to enhance the Brazilian participation, clear & precise information about European calls, information about the selection criteria, broader financing and national funding are essential. Fifth, as support activities that could enhance participation, the most important are the technical & financial support, events to help with the elaboration, higher support & assistance given by National Contact Points in Brazil. Furthermore, a network to facilitate the contact with the most relevant international partners, events that could help with information about Horizon 2020's future calls and activities to help with the elaboration of proposals and project implementation. Sixth, regarding the personal interests, projects with economic impact, improved methods & techniques and the international capacitation of personnel are among the most attractive personal interests to participate in Horizon 2020. However, universities show more interest in publications, while enterprises show more interest in projects with economic impact.

6. CONCLUSIONS

With the ever-growing push towards a "knowledge-based economy", knowledge has become an important aspect when considering the productive processes of enterprises and it has even started to take a fundamental role in economic development. Cooperation between universities, enterprises and the government aiming for technological development is a recurrent aspect of national development policy. Moreover, a phenomenon such as globalization has brought consequences to modern societies such as the internationalization of production, of societies and, specially, of cooperation for technological development. Therefore, international cooperation has increasingly gaining space in public policy with the elaboration of specific strategies for the internationalization of Research & Development of many countries and regions, seeking to have access to external knowledge, infrastructures, markets, among others.

In this context, this project intended to research the barriers that have hindered Brazilian participation in FP7 and H2020, as well as aspects that can potentially enhance the participation of Brazilian ST&I institutions in Horizon 2020. A public policy cannot be formulated and implemented for a general public, but must be targeted to specific groups, in order to be effective. The importance of a cross-analysis lies on the advantage of disaggregating groups and therefore identifying that different organizations define barriers to the participation in European calls differently. Likewise, factors that motivate and create incentives for an increased participation differ drastically depending on the organization.

This research reached 481 Brazilian ST&I institutions that answered an online survey, whose aim is to identify aspects that have hindered the Brazilian participation in FP7 or H2020 and that can potentially enhance it. More than half of the sample obtained consists of small, medium & large enterprises. Consequently, most of the answers came from directors and managers. There is a clear geographic concentration of Brazilian ST&I institutions in the Southeast and South, as already diagnosed by B.BICE (2015), and that still presents the challenges the Brazilian Ministry for Science, Technology and Innovation intend to overcome. Furthermore, there is high concentration within the regions, as for example, the southeast is strongly concentrated in São Paulo and Rio de Janeiro.

Engineering was the largest scientific field among the organizations that have sent a proposal, followed by IT, energy, nanotechnology, sustainable agriculture and bio economy. Surprisingly, two fields that are considered by the European Union as priority fields do not appear as frequently. Besides IT, energy, food security and health present the highest rejection rate among all the scientific fields that submitted a proposal under FP7 or H2020. Even though there is a low participation rate of Brazilian institutions in FP7 and H2020 and a significant lack of information about these programs, the intention to submit a future proposal under Horizon 2020 comprehends 69,18% of the sample.

Universities and public research institutes are expressively the largest group that sent proposals under FP7 and H2020, counting together more than 60% of the total. There is a considerable lack of information of Brazilian ST&I institutions concerning the programs FP7 and H2020 and there is strong evidence that the misinformation level remains equal from FP7 to H2020 and affects mostly the enterprises. On the other hand, universities and public research institutes are relatively less affected by lack of information. Regarding the scientific field, the lack of information has different effects on different scientific fields. Marine sciences is the scientific field more informed about European programs.

There is a high level of disinformation between Brazilian ST&I institutions about European ST&I programs, more than half does not know anything about these programs. This is explained mainly by the unawareness of where to find information, as well as because nobody has ever reached these institutions and explained what the program is. Furthermore, those who have had access to little information find them difficult to understand because of the technical language, likewise they are unclear and unprecise. Enterprises and private research institutes are the most affected by the lack of information.

Then, in order to enhance the participation of Brazilian ST&I institutions in Horizon 2020, a public policy must formulate measures to inform more efficiently Brazilian ST&I institutions, with focus on those more affected by the lack of information – the enterprises and private research institutes. Furthermore, other than lack of information, the existing information was defined as unclear and unprecise. Therefore, in order to enhance the Brazilian participation, clear & precise information about European calls, with a simplified language and precise information about the selection criteria are essential.

Information networks to inform targeted groups about the European programs, as well as the European calls, about the funding opportunities and developing a database that gathers all the information about potential partners from a specific area that are interested in cooperating with Brazilian institutions. Then, formulating clearer and more precise information about Horizon 2020 and its selection criteria. Additionally, the lack of time to prepare a proposal, as well as the difficulty of finding a proper partner, unite their competences and prepare a project, is pointed by ax expressively high amount of participants as a great barrier that have hindered the participation of many Brazilian institution in H2020.

Regarding the identified barriers, the competitiveness of European programs and the difficulty of finding proper partners have significantly hindered the Brazilian participation in FP7 and H2020. The lack of information affects more significantly enterprises, while universities and research institutes are more affected by the lack of up-to-date information and the lack of experience in European calls. Institutions that had all and some of their proposals rejected, pointed the lack of complementation of the consortium as an important reason as to why there was no further participation. Furthermore, the lack of time to elaborate the proposal was amongst the greatest barriers to have a greater success in FP7 and H2020.

The lack of time to elaborate competitive proposals was pointed by all participants who submitted a proposal as a very important barrier to submit proposals. Concerning the elaboration of a competitive proposal, the participants had mostly difficulty to convince the organization to support them with financial commitment, as well as finding proper partners and also the long time necessary to elaborate a competitive proposal. Then, among the Brazilian institutions that do not intend to submit a proposal, the lack of information, lack of national funding, the highly competitive programs and being part of a non-priority field were the greatest aspects that have hindered the participation of these actors. Universities and research institutes are more affected by the lack of financial resources and lack of information while enterprises are most affected by the lack of information.

Furthermore, the lack of funding opportunities was the second most important barrier to further participation of Brazilian institutions in H2020. National public funding is the preferred funding opportunity among enterprises, however, other institutions give relatively the same level of importance to all the different kinds of funding opportunities. Also, the ongoing funding opportunities were classified as narrow and the widening of funding, covering the innovation process as a whole, would potentially increase the participation in H2020. The limited capacity of national funding institutions to support Brazilian institutions in ST&I projects was expressive pointed as a barrier and a fact that could enhance international cooperation.

As important results of international cooperation, the business aspect was in general pointed as very important, followed by collaborative projects, infrastructure, personnel and publications. Once regarding the organization type, enterprises tend to prefer the business aspect as the most important result and publications as less relevant. On the other hand, universities give extra importance to publications. Other organizations give relatively the same level of importance to all the mentioned aspects.

Since Horizon 2020, Brazilian ST&I institutions were excluded from the automatic funding from the European Union. However, is important that the Brazilian government create alternative funding programs that compensate the exclusion of Brazil from the automatic funding by the European programs. That is, lack of financial resources was frequently pointed as a barrier to further participation and specially the desire of improvements the national funding opportunities to support Brazilian institutions to cooperate internationally. There lies the importance of the creation of alternative funding, in order to enhance international cooperation. Funding opportunities were also pointed as narrow and could be include also financial resources to support elaboration of proposals, as well as costs concerning personnel, among others.

National funding opportunities to international cooperation per se do not solve the greatest challenges Brazilian ST&I institutions face. A strategic framework in harmony with the ENCTI (2016) aiming to achieve long-term goals and implement funding is of high importance to improve the participation in Horizon 2020. The identified barriers are important to advise future policy-making. As important as the barriers are the conditions, support activities and criteria pointed by the participants as very important to enhance the Brazilian participation in H2020.

Organization pointed out as main goal that could stimulate the participation in Horizon 2020 would be the access to financial resources, by far the most frequent answer, the development of new products, and the improvement of scientific and technological knowledge. Then, universities see international visibility, mobility, financial resources and gains of knowledge as the main goals in international cooperation, while medium & large enterprises focus on financial resources, competitive advantage and the development of new products & services.

As support activities that could enhance participation, the most important are the technical & financial support, events to help with the elaboration, higher support & assistance given by National Contact Points in Brazil. Furthermore, a network to facilitate the contact with the most relevant international partners, events that could help with information about Horizon 2020's future calls and activities to help with the elaboration of proposals and project implementation.

Regarding the personal interests of the participants, projects with economic impact, improved methods & techniques and the international capacitation of personnel are among the most attractive personal interests to participate in Horizon 2020. However, universities show more interest in publications, while enterprises in projects with economic impact. Finally, again it is important to insist, if increased participation in Horizon 2020 is desired by the Brazil government and the European Union, a public policy elaborating measures that are targeted to specific groups must be introduced. Thus, factors that motivate and create incentives for an increased participation differ drastically depending on the organization.

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ANNEX 1. QUESTIONNARIE APPLIED FOR THE SURVEY

Questionário INCOBRA

O presente questionário foi desenvolvido pelo projeto INCOBRA, tendo como alvo as organizações brasileiras que apresentaram propostas para os programas nacionais / regionais brasileiros de apoio à Ciência, Tecnologia e às actividades de Inovação entre os 2007-2016.

Este estudo tem dois objetivos: (a) identificar as barreiras e dificuldades que impedem uma participação mais ativa das organizações brasileiras nos programas da União Europeia (UE), nomedamente, no FP7 e Horizonte 2020 e; (b) explorar os incentivos e motivações que podem potencialmente incrementar a participação das mais diversas organizações brasileiras no atual programa da União Europeia - o Horizonte 2020.

Horizonte 2020 é o principal programa de Pesquisa e Inovação atualmente em curso financiado pela Comissão Europeia, com cerca de 80 bilhões €, de financiamento disponível ao longo de 7 anos de implementação do programa (de 2014 a 2020). O programa está aberto à colaboração internacional com países como o Brasil, mediante a certas condições. Este programa oferece, nesse sentido, oportunidades de financiamento muito siginificativas para as organizações brasileiras no campo da Ciência, Inovação e Tecnologia.

Mais informações sobre o programa Horizonte 2020

A sua opinião é muito importante para nós, e desde já, agradecemos pela sua participação.

O consórcio do Projeto INCOBRA.

Há 29 perguntas neste questionário

ZSI Limesurvey - Questionário INCOBRA

Participation in FP7 and Horizon 2020

() Você já participou em chamadas bilaterais, que apoiam a colaboração entre o Brasil e um país europeu, em particular (por exemplo, Brasil & França; Brasil & Alemanha)?

Favor escolher apenas uma das opções a seguir:

- Sim

- Não

() Já alguma vez apresentou um projeto no âmbito do FP7* ou no atual Horizonte 2020?

Favor escolher apenas uma das opções a seguir:

- Sim

- Não

() O seu projeto foi aprovado?

Só responder essa pergunta sob as seguintes condições:

A resposta foi 'Sim' na questão '2 [ParticipationEU]' (Já alguma vez apresentou um projeto no âmbito do FP7* ou no atual Horizonte 2020**?)

Favor escolher apenas uma das opções a seguir:

Sim

Não

() Quais foram ou são dificuldades que você encontrou durante o processo de preparação e de submissão da proposta?

Por favor, escolha as opções que se aplicam:

Houve dificuldade de encontrar os parceiros mais adequados.

Houve dificuldade de convercer a minha instituição para fazer parte do consórcio porque nos foi pedido um compromisso financeiro.

Foi difícil combinar e unir as diferentes competências dos parceiros no projeto.

A preparação da proposta foi uma tarefa muito longa e demorada.

Eu tive que fazer todo o trabalho da proposta sozinho porque a minha instituição não estava preparada para me ajudar.

Outros:

() Levando em consideração a sua experiência bem sucedida, você tem alguma recomendação a fazer aos futuros candidatos brasileiros quando submeterem as propostas?

Por favor, coloque sua resposta aqui:

() Você tem interesse em participar em evento(s) para partilhar sua experiência com os futuros candidatos brasileiros?

Sim

Não

() Por favor, preencha seus dados de contato:

Por favor, coloque sua(s) resposta(s) aqui:

Nome:

Email:

() Por que a sua proposta não foi aceita?

A proposta não abordava adequadamente os objetivos da chamada.

A avaliação apontou para uma falta de boa execução da proposta.

A avaliação salientou a falta de complementaridade do consórcio.

A avaliação apontou que os impactos do projeto não foram adequadamente considerados.

Falta de tempo para preparar uma proposta competitiva, porque o consórcio foi tardiamente estabelecido.

Outros:

() Por que você nunca apresentou uma proposta no âmbito do FP7 ou Horizonte 2020?

Eu não tinha informações sobre os programas da União Europeia de Pesquisa e de Inovação.

Eu não tinha informações das condições de financiamento da União Europeia em matéria de Pesquisa e de Inovação.

Não houve uma linha de financiamento das instuitições brasileiras que permitisse a participação da minha organização.

Os processos de candidatura eram muito longos e complicados e foi considerado que o trabalho não valia o investimento.

O tema prioritário do FP7. / ou H2020 não coincide com a minha área de pesquisa.

Na minha instituição está faltando a capacidade de gestão para lidar com esses programas e projetos.

Os programas são muito competitivos e orientados principalmente para organizações com capacidade crítica e já familiarizadas com os projetos de Pesquisa e Inovação da União Europeia.

Eu não consegui encontrar os parceiros mais adequados, quer seja do campo acadêmico, quer seja do campo industrial.

Devido às experiências negativas de vários dos meus colegas, eu estou desanimado a apresentar qualquer proposta para o Horizonte 2020.

Outros:

() Você pretende apresentar uma proposta no âmbito do Horizonte 2020*?

Favor escolher apenas uma das opções a seguir:

Sim

Não

() Por que você não apresentou uma proposta no âmbito Horizonte 2020*?

Eu não tenho conhecimento sobre os programas da União Europeia de Pesquisa e de Inovação.

Os procedimentos são muito longos e complicados.

O tema prioritário de Horizonte 2020 não coincide com a minha área de trabalho atual.

Na minha instituição está faltando a capacidade de gestão para lidar com esses programas ou projetos deste âmbito.

Os programas são muito competitivos e orientados principalmente para organizações maiores que já tiveram experiências com projetos da União Europeia.

Eu acredito que vai ser dificil encontrar os parceiros adequados, tanto do campo acadêmico e como do campo industrial.

A falta de recursos financeiros das organização brasileiras desmotiva a minha organização de apresentar propostas.

Nós preferimos focar em propostas apresentadas para chamadas bilaterais entre o Brasil e determinados países membros da União Europeia.

Outros:

How well informed?

() Qual é o seu nível de informação sobre as chamadas lançadas no âmbito do FP7* publicadas no período 2007-2013? Escolha apenas uma das seguintes opções?

Não informado

Pouco informado

Moderadamente informado

Bem informado

Muito bem informado

() Qual é o seu nível de informação sobre as chamadas lançadas da União Europeia no âmbito do Horizonte 2020*, o atual Programa de Pesquisa e de Inovação (2014-2020)?

Não informado

Pouco informado

Moderadamente informado

Bem informado

Muito bem informado

() Por que que você não está informado?

Eu não conheçco os sites na internet onde eu posso encontrar tais informações.

Ninguém nunca me explicou o que são os programas FP7 e Horizonte 2020.

A minha organização nunca obteve informações atualizadas sobre tais programas.

Eu sou novo neste área de projetos europeus de Pesquisa e de Inovação.

Outros:

() Por que você não está bem informado?

Recebi informações, mas é difícil compreender o jargão técnico das chamadas europeias.

Eu sou novo nesta área e, portanto, todas as informações relacionadas aos programas da União Europeia não estão no meu centro de interesse.

A minha organização nunca recebeu informações sobre esses programas.

A colaboração na área da Pesquisa Internacional não tem sido, até ao momento, uma prioridade da minha organização.

Outros:

Interest in international STI collaboration

() Qual é o objetivo mais importante de cooperação de Pesquisa e Inovação internacional,

na perspectiva da sua organização?

1=Sem importância 10=Muito importante

Por favor, escolha a resposta adequada para cada item:

1 2 3 4 5 6 7 8 9 10

Pessoal: Intercâmbio de pessoal de (acolhimento e envio de pessoal)

Projetos: colaborativos em Pesquisa e Inovação (trabalhando com parceiros europeus)

Publicações: Colaboração conjunta em publicações científicas

Negócios: cooperação tecnológica com potencial comercial com parceiros no exterior

Infraestruturas e equipamentos: acesso a infraestruturas de Pesquisa internacional

() Por favor, indique o interesse da sua organização nas seguintes oportunidades de financiamento:

1=Sem importância 10=Muito importante

Por favor, escolha a resposta adequada para cada item:

1 2 3 4 5 6 7 8 9 10

Chamadas do Estado Brasileiro em Pesquisa, Tecnologia e Inovação (Finep, BNDES, Fapesp, Fape´s, Embrapii, etc..)

Chamadas bilaterais entre o Brasil e países membros da União Europeia com foco em Pesquisa e Inovação;

Programas de Pesquisa e Inovação (como o Horizonte 2020 ou projetos colaborativos);

As chamadas internacionais entre o Brasil e outros países, fora da Europa (por exemplo, Brasil e EUA, etc).

() O que poderia ser um incentivo para garantir a participação da sua organização no âmbito do programa europeu de Pesquisa e Inovação - Horizonte 2020?

Por favor, escolha as opções que se aplicam:

Aumento da visibilidade internacional e reconhecimento do nosso trabalho.

Inclusão nas redes internacionais em nossos campos de trabalho.

Obtenção de vantagem competitiva no âmbito empresarial, pelo acesso a novos mercados.

Desenvolvimento de novos produtos ou serviços com potencial para a exploração de negócios.

Desenvolvimento de parcerias relevantes com diversos organismos em nossos campos de trabalho.

Acesso a recursos financeiros importantespara a execução dos projetos.

Aumento do conhecimento científico-tecnológico no nosso campo de atuação e contribuição para a resposta aos desafios societais e industriais.

Outros:

() Qual dos seguintes aspectos poderia potencialmente aumentar a sua participação noprograma Horizonte 2020* dentro da sua organização?

Por favor, escolha as opções que se aplicam:

Ter informações claras e precisas sobre chamadas da União Europeia no quadro do Horizonte 2020, diretamente ligadas ao meu setor.

Ter acesso às informações de organizações da UE e suas áreas específicas e interesses na implantação de cooperação com as organizações brasileiras.

Ter informações claras sobre os critérios de elegibilidade, seleção e financiamento para as organizações brasileiras.

Ter apoio técnico durante a preparação da proposta.

Ter apoio financeiro dentro da minha organização para a preparação da proposta.

Ter mais encontros para formação e informações sobre as oportunidades de financiamento no quadro das propostas da União Europeia.

Ter um banco de dados on-line onde eu poderia identificar parceiros de países da UE na nosso área de trabalho.

Eu gostaria que as oportunidades de financiamento fossem mais abrangentes (por exemplo, provisão para pagamento de pessoal de pesquisa)

Outros:

() Quais seriam as atividades de apoio que poderiam potencialmente aumentar a sua participação em projetos no âmbito do Horizonte 2020*?

Participação em conferências científicas entre os parceiros da União Europeia.

Participação em reuniões de networking.

Criação de redes para facilitar o contato com os parceiros internacionais mais relevantes possibilitando assim uma partilha de competências em interesses centrais entre Brasil e União Europeia.

Serviços de orientação e treinamento a serem disponibilizado para os futuros participantes no Horizonte 2020.

Sessões de informação regulares sobre chamadas lançadas no âmbito do Horizonte 2020, tanto para as universidades quanto para as empresas.

Maior assistência e orientação dadas pelo(s) Ponto(s) de Contato Nacionais brasileiros.

Atividades de formação para a preparação da proposta e execução do projecto.

Outros:

() O que você espera ganhar com a participação bem sucedida no Horizonte 2020*?

Por favor, escolha as opções que se aplicam:

Publicações em revistas e livros internacionalmente revisados

Pessoal capacitado internacionalmente / (por exemplo, Mestrado, Doutoramento, Pós-doc)

Prémios

Participação em conferências científicas, seminários ou workshops

Patentes concedidas

Acordos de licenciamento

Métodos e técnicas significativamente melhorados

Impactos econômicos

Impactos sociais

Outros:

Information about participant

() Qual das seguintes alternativas melhor descreve a sua organização?

Por favor, escolha as opções que se aplicam:

Universidade / Faculdade

Instituto Público de Pesquisa / Centro de Pesquisa Público

Instituto Privado de Pesquisa / Centro de Pesquisa Privado

Micro empresa (renda anual de até R $ 360,000);

Empresa de pequeno porte (renda anual de R $ 360,001 até R $ 3.600.000);

Autoridade pública / Agência

Outros:

() Qual das seguintes alternativas melhor descreve o seu papel na sua organização?

Por favor, escolha as opções que se aplicam:

Pesquisador

Pesquisador-líder / coordenador de pesquisa

Diretor

() Por favor indique o Estado da organização:

Favor escolher apenas uma das opções a seguir:

Acre

Alagoas

Amapá

Amazonas

Bahia

Ceara

Distrito Federal

Espírito Santo

Goiás

Maranhão

Mato Grosso

Mato Grosso do Sul

Minas Gerais

Pará

Paraíba

Paraná

Pernambuco

Piauí

Rio de Janeiro

Rio Grande do Norte

Rio Grande do Sul

Rondônia

Roraima

Santa Catarina

São Paulo

Sergipe

Tocantins

Outros

() Qual das seguintes alternativas melhor descreve o setor de atuação de sua organização?

Por favor, escolha as opções que se aplicam:

Ciências Marinhas

Bio-Economia

Segurança alimentar

Agricultura sustentável

Energia

Nanotecnologia

Tecnologia da Informação

Outros:

() Você estaria disposto a fornecer mais informações em um grupo de discussão / entrevista (por telefone ou skype)?

Favor escolher apenas uma das opções a seguir:

Sim

Não

() O seu contato de correio electrónico é:

Só responder essa pergunta sob as seguintes condições:

() Você gostaria de receber a newsletter do projeto INCOBRA?

Favor escolher apenas uma das opções a seguir:

Sim

Não

Obrigado por sua participação no inquérito!

Se você tem dúvidas sobre a pesquisa entre em contato com os responsáveis brasileiros por meio dos seguintes e-mails: :

Financiadora de Estudos e Projetos - Finep

Julio Cesar imenes – jcimenes@finep.gov.br

Vívian Pires - vcpires@finep.gov.br

FAPESP

Sergio Queiroz - squeiroz@ige.unicamp.br

Adicioalmente, se você está interessado em ter mais informaçõs sobre a pesquisa, entre em contato com os líderes de tarefa

responsáveis do Centro de Inovação Social, Viena, Áustria (Teresa de Oliveira, deoliveira@zsi.at)

Clique aqui se você quiser receber a Incobra Boletim informativo:

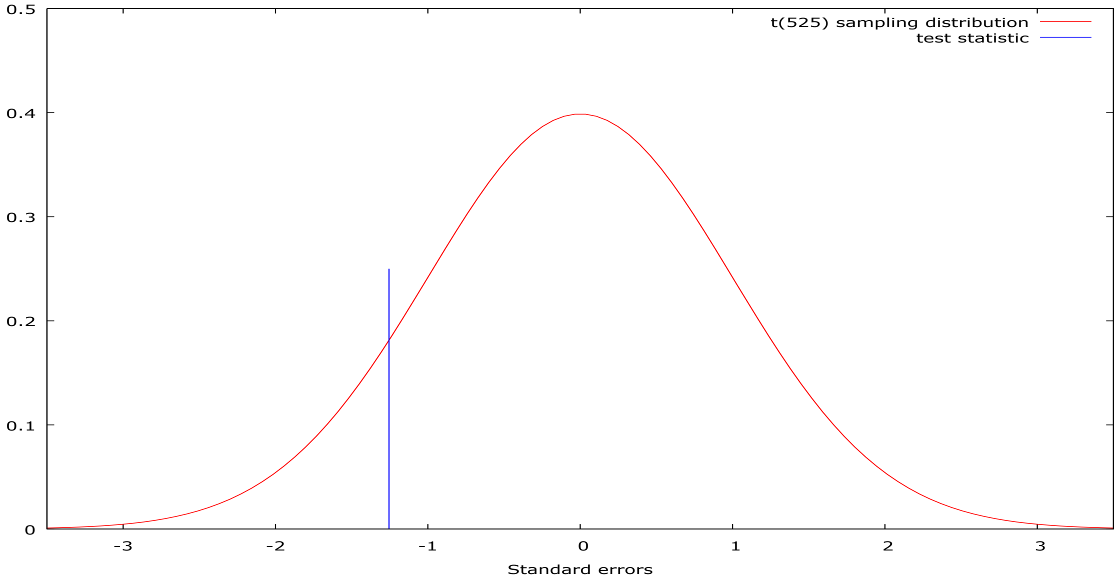
Para outras dúvidas sobre o projeto Incobra não hesite em entrar em contato com o coordenador do projeto:

André Barbosa na Sociedade Portuguesa de Inovação - Porto, Portugalandrebarbosa@spi.pt

Atenciosamente

O consórcio do projeto INCOBRA

ANNEX 2. ANOVA test for information about FP7 and Horizon 2020.



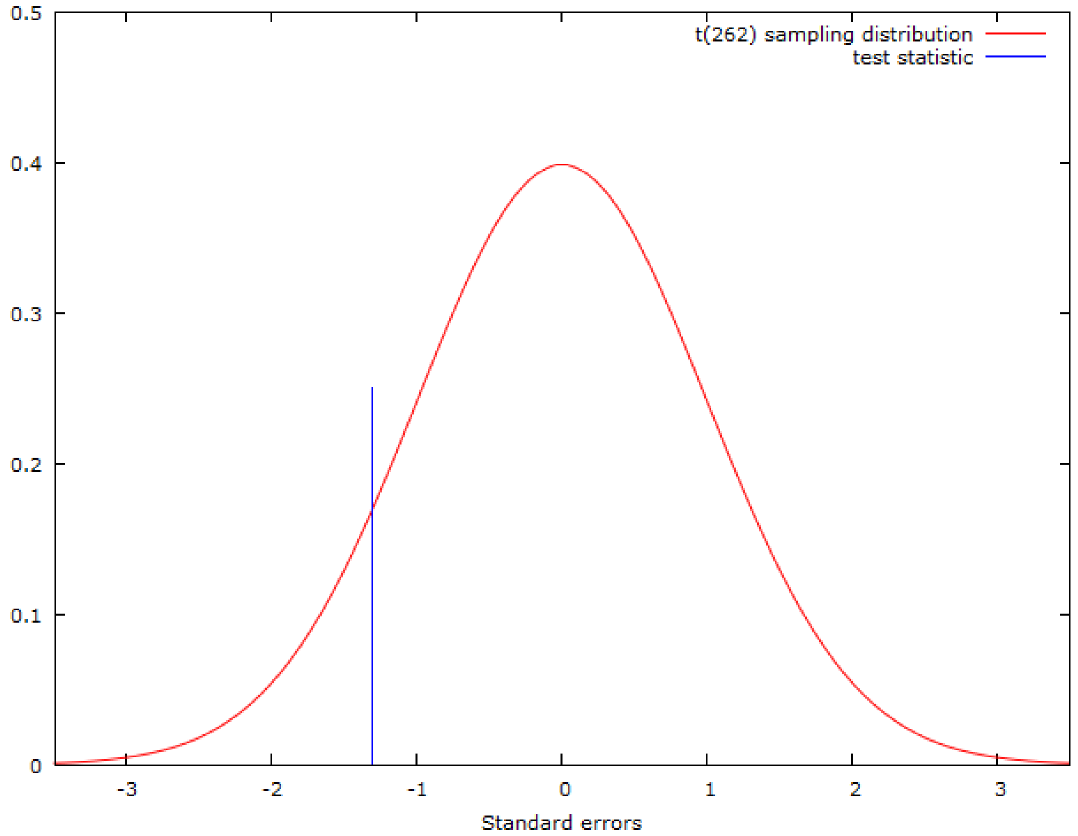
Null hypothesis: Difference of means = 0

Sample 1:
n = 267, mean = 1.61798, s.d. = 0.811185
standard error of mean = 0.0496437
95% confidence interval for mean: 1.52023 to 1.71572

Sample 2:
n = 260, mean = 1.71154, s.d. = 0.899089
standard error of mean = 0.0557591
95% confidence interval for mean: 1.60174 to 1.82134

Test statistic: t(525) = (1.61798 - 1.71154)/0.0745546 = -1.25493
Two-tailed p-value = 0.2101
(one-tailed = 0.105)

ANNEX 3. ANOVA test for unawareness of where to find the information in the internet and lack of up-to-date information.



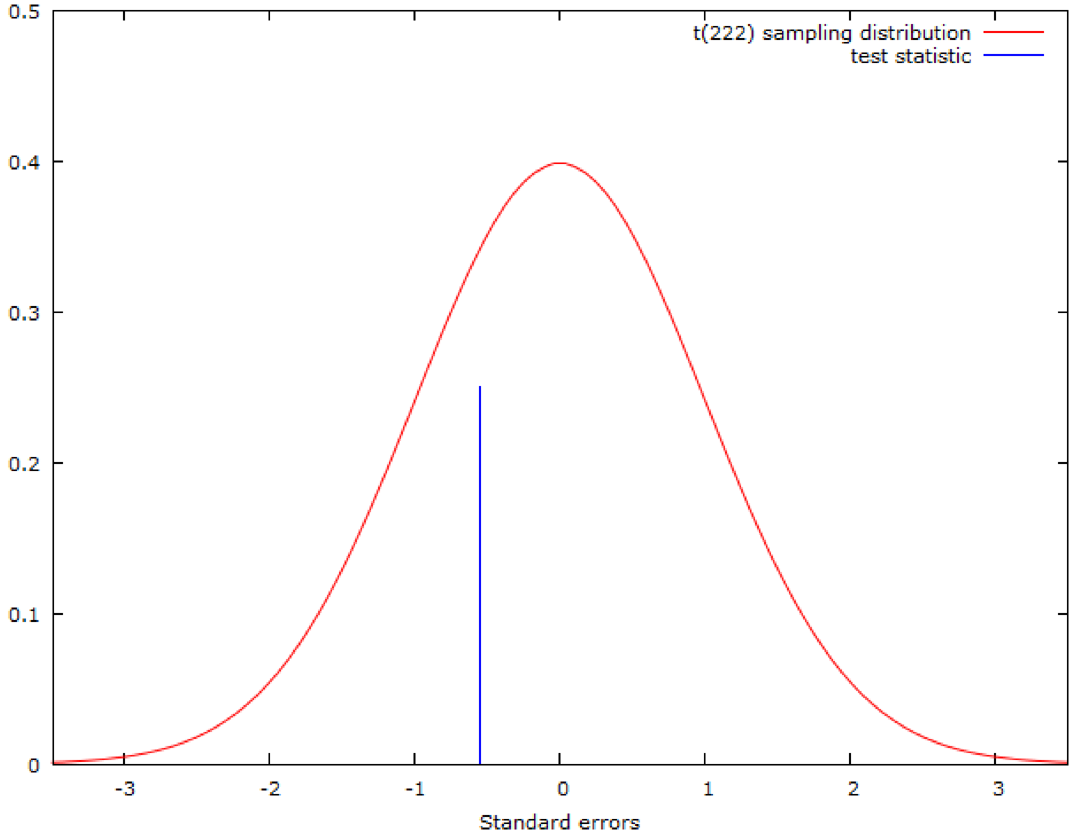
Null hypothesis: Difference of means = 0

Sample 1:
n = 132, mean = 1.63636, s.d. = 0.482878
standard error of mean = 0.0420292
95% confidence interval for mean: 1.55322 to 1.71951

Sample 2:
n = 132, mean = 1.71212, s.d. = 0.454499
standard error of mean = 0.0395591
95% confidence interval for mean: 1.63386 to 1.79038

Test statistic: t(262) = (1.63636 - 1.71212)/0.057718 = -1.31255
Two-tailed p-value = 0.1905
(one-tailed = 0.09524)

ANNEX 4. ANOVA test for not comprehending the technical language and not priority to cooperate internationally.



Null hypothesis: Difference of means = 0

Sample 1:
n = 112, mean = 1.83036, s.d. = 0.377006
standard error of mean = 0.0356237
95% confidence interval for mean: 1.75977 to 1.90095

Sample 2:
n = 112, mean = 1.85714, s.d. = 0.3515
standard error of mean = 0.0332136
95% confidence interval for mean: 1.79133 to 1.92296

Test statistic: t(222) = (1.83036 - 1.85714)/0.0487051 = -0.549957
Two-tailed p-value = 0.5829
(one-tailed = 0.2915)