

# The 'added value' of researchers: the impact of doctorate holders on economic development

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## 1. Introduction

This manuscript provides an exploration of the professional trajectories of doctorate holders in an emergent economy. It presents an analysis of original data from more than 4,000 PhDs<sup>1</sup> in Brazil and examines it from the perspective of the country's research and innovation situation. The manuscript is intended to address two main areas of interest: the ways in which an emergent country with around 13,000 PhDs graduating per year is creating advanced capabilities; and the economic and social impacts of these trends.

Fostering research training, mainly through the PhD degree, has been an important feature of science, technology and innovation (ST&I) policies around the world since the 1950s. From the policy perspective, qualified researchers are seen as a means to widen innovation capacity as well as to improve economic and social wellbeing. From the individual perspective, achieving a PhD is seen traditionally as a path to an academic career or to a research career in the private or public sector, as well as a way to fulfill one's own personal interest and curiosity.

In modern knowledge-based economies, where research and innovation are important drivers of economic expansion, human capital – and particularly a highly educated workforce (including those with a doctoral education) – is acknowledged as one of the prerequisites for economic development and growth (Leitch, 2006; Halse and Mowbray, 2011; Salter and Martin, 2001; Tremblay, 2005; Neumann and Tan, 2011).

While doctoral education is still seen as a key component of ST&I policies, the changing nature of job markets poses some challenges to ensuring that investment in PhDs delivers the expected positive outcomes. In a number of countries, supply of doctoral graduates exceeds demand for them. In itself this situation is not uncommon: except in conditions of full employment, some degree of unemployment is always present. Notwithstanding, it is worth noticing that since the 1990s the world has seen an increase in the number of doctorate enrollments and graduates, and at the same time a relative slowing down of recruitment of researchers, particularly in academic jobs (Mangematin, 2000; Zusman, 2005; Taylor, 2011; Cyranoski et al., 2011, Neumann and Tan, 2011).

This situation suggests a mismatch between human capital formation and research and innovation capacity, fueling the debate about the role of public funding in professional researchers' education and their social and economic impacts (Enders, 2002; Auriol et al., 2012). Indeed, the general debate about the economic benefits of research – including the provision of trained research personnel and their implications for public policy (Pavitt, 1991; Salter and Martin, 2001) – has become increasingly focused on highly skilled graduates and the changing landscape of the labor market.

The consequences of this changing landscape are twofold. From the supply side, it is necessary to rethink policies and PhD programs to adjust them to this new reality. This involves both curricular and institutional changes, which can bring a combination of new knowledge promotion and a focus on practical problems, with a closer alignment between the skills developed in doctoral programs and the need of industry and other non-academic sectors, in a more diverse and multi-faceted model (Taylor, 2011; Halse and Mowbray, 2011; Kobayashi, 2012). However, as pointed out by Enders (2002),

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<sup>1</sup> While PhD is not the only path to gaining a doctoral level qualification, it is the most traditional form. This manuscript will therefore refer to doctorate holders, doctoral graduates and PhDs interchangeably.

How to cite this book chapter: BIN, A.; SALLES FILHO, Sérgio Luiz M.; COLUGNATI, Fernando; CAMPOS, F. R.; The 'added value' of researchers: the impact of doctorate holders on economic development. Auriol, L. et al. (2016) "The Science and Technology Labor Force: The Value of Doctorate Holders and Development of Professional Careers", Springer.

discussions about the reorganization of doctoral education are dominated by controversial debates on the extent to which higher education should reorganize to change its modes of knowledge production (e.g. creating more applied and interdisciplinary knowledge). From the demand side, the situation suggests the need to facilitate the development of the PhD labor market through incentives to retain high-qualified researchers in different sectors and roles.

Tracking the career destinations of doctorate holders is a good way to better understand this situation in different regions and countries, therefore enabling policy design, both from the supply side (doctoral programs) and from the demand side (academia, industry, government and other sectors). This kind of initiative is traditionally under-researched when compared to studies on undergraduates as presented by Raddon and Sung (2009). Nevertheless, the research and higher education agencies of several countries have conducted such studies to measure the multidimensional impacts of research and researchers, as a way to account for the public investments in this area and to support future efforts.

Some empirical work in this area has been produced in the last few decades, discussing the impacts of PhD training policies in important dimensions (e.g. employment, mobility, skills generation, self-satisfaction, rewards, collaboration). However, few of them analyze these features against the backdrop of more comprehensive indicators on innovation and economic growth at the national or even the regional level. In addition, there is an evident lack of studies discussing this changing landscape in less developed and non-OECD countries.

The aim of this paper is to contribute to filling this gap by providing an investigation of the impact of doctoral training on the subsequent careers of PhDs in Brazil. Some selected studies on doctoral education and their economic benefits are presented in the second section, forming the background for discussion of the Brazilian case. The third section explains the research methods and tools employed in our case study, while the fourth section presents the main findings and discussion. Finally, the last section presents some general conclusions, as well as an agenda for future studies.

## **2. Prior Literature**

There have been many studies in recent years on the impact of doctoral education on the economy and society. Discussing the contribution that publicly funded research has on economic growth, Salter and Martin (2001) emphasize that the capacities and knowledge background of skilled graduates is a distinctive benefit of publicly funded research. Such graduates are oriented towards solving complex problems, performing research and developing ideas.

Casey (2009) distinguishes several benefits of doctoral education: the individual private returns from the possession of a PhD qualification, commonly reflected in higher wages; the contribution of doctorate holders to increasing the pool of knowledge; the teaching/learning effects associated with their engagement in the higher education sector; the potential transfer of new knowledge to industry and consequent contribution to the next generation of new or improved products, processes and services; and finally the spillovers of the 'embodied' knowledge of PhDs in the work environment e.g. creativity, problem solving skills, hypothetical thinking. This last type of contribution is similar to Cohen and Levinthal's (1989) concept of 'absorptive capacity', understood as the role of R&D in enhancing a firm's ability to assimilate and exploit existing information. Other authors such as Lee et al. (2010), Tremblay (2005), Neumann and Tan (2011), Cruz-Castro and Sanz-Menéndez, 2010 and Connor and Brown (2009) also discuss these kinds of impacts. Roach and Sauermann (2010) and Garcia-Quevedo et al. (2012), in their work on PhDs engaged in firms, also note the impact of PhDs in creating favorable environments for R&D and enhancing their firms' participation in external

networks with the scientific community. Although most research has focused on the economic effects of PhDs, Raddon and Sung (2009) suggest the importance of other wider social impacts such as political engagement, community development and cultural contributions.

In spite of this diversity in the perceived impacts of PhDs and the importance of doctoral education, some effects are difficult to quantify. Connor and Brown (2009) claim that evidence linking graduates' employment and their skills with economic performance are problematic, mainly because skills are just one factor among many that contribute to innovative behavior and economic growth at the micro level. Similarly, other kinds of impact are difficult to measure, such as the extent to which increases in the pool of knowledge are a consequence of doctoral education.

Over the last two decades there has been a significant increase in studies tracing the career patterns of doctorate holders, in order to attempt to measure some of their potential impacts. More recently, these studies have focused on the mismatch problem referred to in the first section, expanding their scope to find out how doctorate holders are securing formal jobs, including mobility and migration aspects, but also how they are performing in their jobs: type of contract, earnings and involvement with teaching and research activities.

Institutional initiatives include the *Careers of Doctorate Holders* project, developed in 2004 by the OECD in partnership with UNESCO (OECD/UNESCO, EUROSTAT, 2007; Auriol, 2010; Auriol et al. 2012); the *Survey of Earned Doctorates* and *Survey of Doctorate Recipients* by the American National Science Foundation and the National Institutes of Health in conjunction with other federal agencies (Chang and Milan, 2012; NSF, 2013a; NSF, 2013b); *Destinations of Leavers from Higher Education (DLHE)* and *DLHE Longitudinal Survey (Vitae, 2010)*; and the Graduate Destination Survey (GDS) (Graduate Careers Australia, 2013). Such studies are good examples of systematic efforts to map the incorporation of highly qualified human resources in labor market. They also offer methodological references for this kind of study in other countries (see, for instance, the Portuguese case in GPEARI/MCTES, 2011).

These studies show the concentration of doctorate holders' employment in the academic sector, albeit with an intensification of short-term contracts in recent years, including post-doctorate positions.<sup>2</sup> There is also an increasing trend in some countries (such as the USA) for PhDs to be employed in non-academic sectors, particularly those who graduated in the fields of engineering and sciences.

In addition, the majority of PhD holders have a relatively smooth transition to employment after graduation, engaging in some type of research career. It is also possible to find some mobility trends in terms of changes of jobs, regions and countries. Unemployment rates for PhDs are almost always relatively low, and premium wages for doctorate holders are common (Mangematin, 2000; Enders, 2002; Auriol et al., 2012; Neumann and Tan, 2011; Cruz-Castro and Sanz-Menéndez, 2005; Raddon and Sung, 2009; Heitor et al., 2014; Zusman, 2005; NSF, 2013a; NSF, 2013b; Vitae, 2010). However, there are important differences among countries and knowledge fields (Basil and Basil, 2006; Flynn et al., 2011; Innes and Feeney, 2012; Lee et al., 2010; Kobayashi, 2012; Luchilo, 2010), and time period since graduation is also a factor.

Other studies have investigated more intangible aspects, such as personal motivations for PhD training (Mangematin, 2000), expectations and preferences of PhDs about

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<sup>2</sup> Post-doctorate (or post-doc) refers to a person who has taken a doctoral degree and spends some further time training in research before taking tenure-track jobs. In some countries like Brazil, it is also possible to get post-doc positions temporarily even after taking a permanent job position as a mean to improve some research skills or develop a new research field.

future employment based on the perceived rewards of different careers (Roach and Sauermann, 2010; Gemme and Gingras, 2012; Cruz-Castro and Sanz-Menéndez, 2010), self satisfaction and perception of the importance of a PhD to professional trajectory (Enders, 2002). From the labor market point of view, studies have examined the determinants of PhDs being hired in non-academic sectors (Garcia-Quevedo et al., 2012; Connor and Brown, 2009), and how the skills and knowledge of advanced degree holders are used in different sectors (Lee et al., 2010; Auriol et al., 2012; OECD, 2012).

These studies have revealed some important findings about changes in the traditional reward systems of the academic and non-academic sectors. There has been some degree of cross-pollination between academia and industry, in terms of both sectors adopting practices typically associated with the other. For example, new pressures on funding in academia have led to increased commercialization and co-working with industry, while industry has adopted some elements of research environments, such as publications and research collaboration (Lee et al, 2010; Roach and Sauermann, 2010). From the point of view of motivations and satisfaction, perceptions are quite diverse depending on the country, field of study and type of employment.

On the whole, these trends demonstrate the need to deal two problems: one quantitative, one qualitative. Firstly, the problem of the number of PhDs exceeding the number of appropriate job opportunities; and secondly, some degree of inadequacy of the skills developed when applied to non-academic employment. From the policy perspective, dealing with the quantitative problem may lead to attempts to restrict the number of PhD enrollments (Zusman, 2005), although such a policy is not generally supported in the specialist literature, since a highly educated workforce (including PhDs) is acknowledged as a prerequisite for economic development and innovation.

Concerning the qualitative problem, the upshot is that new skills need to be developed in doctoral education, catering for those with a stronger or weaker “taste for science” (to use Roach and Sauermann’s (2010)) expression, and addressing the varied and changing needs of the PhD labor market in the higher education sector, industry, government and non-governmental organizations. In general, this means broadening the scope of doctoral education from formal knowledge in disciplinary fields to include other skills, more aligned with Mode 2 of knowledge production (Gibbons et al., 1994; Nowotny et al., 2001), as well as decreasing its traditional and limited self-reproductive function for the academic profession. Broadly speaking this suggests more diversity in organizational and structural forms of research training, in order to suit a multiplicity of careers (Enders, 2002; Zusman, 2005; Gemme and Gingras, 2012; Halse and Mowbray, 2011; Connor and Brown, 2009).

There are a range of existing initiatives in this broad spectrum, including those aimed at supporting elite students to achieve academic positions, such as the NIH Oxford-Cambridge Scholars Program (McCook, 2011); initiatives geared towards interdisciplinary research such as the National Science Foundation’s Integrative Graduate Education and Research Traineeship Program - IGERT (Carney et al., 2006); and even university-industry collaborations such as the UK Engineering Doctorate (EngD) programs (Kitagawa, 2013).

From the demand side, this situation imposes a request for initiatives that can help valuing PhDs in non-academic sectors, thereby widening employment opportunities. In the case of industry, this kind of initiative has well-established links to those that foster further private investment in R&D, which obviously only makes sense if there are economic incentives for innovation.

Besides the extensive set of R&D and innovation policies pursued by countries all over the world, it is interesting to highlight those policies particularly oriented towards increasing the number of doctorate holders employed in firms, such as the Spanish

Program for the Employment of PhDs in Firms (*Acción para la Incorporación de Doctores en Empresas* — IDE) that subsidizes firms willing to contract junior PhDs not previously working in the company for R&D and innovation jobs (see Cruz-Castro and Sanz-Menéndez, 2010 for an evaluation of this program).

Unfortunately, there seem to be few if any such formal initiatives to recruit doctorate holders into the government sector. This is regrettable, since research can and should play a major role in the policy-making process (Johnson and Williams 2011), and PhDs could make a valuable contribution to the government sector in this respect. Enders (2002) adds an important issue within the demand side debate, related to the need for a functional differentiation in the higher education sector, which could also support new possibilities for doctorate holders.

Increasing and even qualifying the offer of PhDs with more up-to-date and relevant skills without dealing beforehand with the demand for these professionals (as well as the conditions to benefit from the knowledge generated from their research), could even exacerbate the problem of supply-demand mismatch. In this way, incentives for R&D efforts in the private sector or for more effective links between research and the policy cycle and for valuing PhDs work in all sectors are essential.

Heitor et al. (2014) discuss the above argument in their presentation of employment indicators for PhDs awarded in Portugal over the period 1970 to 2008. They claim that the significant increase in the number of PhDs in Portugal in this period was accompanied by improvements in scientific and technological development, demonstrated by increases in scientific productivity and gross (total) business expenditure on R&D. The authors refer to this process as the “co-evolution of human capital formation and institutional research capacity building,” since the incentives to PhD training were part of a synchronized set of public policies designed to foster R&D and innovation, and to promote the absorptive capacity needed by emerging regions and countries in order to learn how to use science for economic development.

This is also evident in the Chinese case, as presented by Li et al. (2007) and Yang (2012). Despite only starting in the early 1980s, doctoral education has grown significantly in China in recent decades, becoming a significant part of the country’s R&D and innovation efforts. In spite of some problems with quantitative and qualitative aspects of graduation studies in the country, it can be argued that as economic and market reform came before reform of the higher education system in China, economic prosperity created an increasing demand for PhD graduates.

The same may be said about South Korea, where the increase in the rate of PhD degrees was accompanied by equally elevated rates of GDP and industrial innovation (Marchelli, 2005). The main lesson in these cases is the need of a balanced policy mix that complements and integrates initiatives to foster qualified doctoral education and economic development.

Whilst these are imperatives for the future of doctoral education, it is important to highlight (as Enders (2005) does) that PhD training is not just supposed to meet the demands of the labor market, but to push towards innovative activities and thus the creation of new demands not yet recognized by the labor market.

While some studies regarding doctorate holders in developing countries advocate increasing the number of PhDs as a means of generating social and economic development, there are also concerns about where to employ these skilled graduates outside the academic sector. There are neither large numbers of job vacancies that require a doctoral education, nor a significant premium wage associated with PhD degree (see for instance the Malaysian case in Ng et al., 2011, and the Indian case in Kumar et al., 2012).

The assumption that countries should increase the number of PhDs as a means to generate social and economic development would seem to be a case of 'putting the cart before the horse', inasmuch as their governments first need to address the core problem underlying doctorate education – the demand issue. The mantra of the 'importance of skilled researchers' for bringing economic benefits – widely accepted for more developed countries – may be less clear cut for some less developed ones. To be clear, this does not mean that less developed countries should not aim to increase their highly skilled workforce. But given that these countries face a wide variety of problems, there is no single, cure-all solution.

Given the changing background of supply and demand of PhDs around the world, and the varying patterns of social and economic development of different countries, there is still much scope to explore the benefits of skilled graduates in various developing countries. The cases of China and Korea are probably more stereotypes than archetypes, for the situations among the so-called emerging countries can be very diverse. This gives rise to a number of questions. To what extent can such variables as type of employment, dedication to research, and earnings, be extrapolated from the studies about developed and some emerging countries (namely China and Korea)? And how far do public policies with respect to PhDs take into account the economic and social backgrounds of these less developed countries?

In respect of these questions, the Brazilian case is an interesting one to explore, since the country has also experienced a huge increase in the number of doctoral programs and doctorate holders in the last decade. Furthermore, it is also facing difficulties in generating the social and economic benefits of this doctoral education, because the supply-demand mismatch is also present, in particular due to the relative decrease in employment posts within the academic sector.

However, discussion about the actual and potential demand for these doctorate holders, and the new skills that need to be developed within the Brazilian economic context, is currently inadequate. This is due to the lack of systematic data gathering efforts in the country, such as surveys of doctorate holders' careers aimed at measuring both objective and subjective issues (employment positions and perceptions of doctoral graduates). Thus, comprehensive data and analysis of PhDs in Brazil is quite limited, despite the existence of two important (but not systematic) studies: Velloso (2004) and CGEE (2010).

### **3. Methods**

The data and analysis presented in this manuscript are part of a more comprehensive research project evaluating scholarship programs of São Paulo Research Foundation (FAPESP), a Brazilian research agency that supports research in São Paulo State. The evaluation comprised the undergraduate research program, as well as master's and doctoral programs.

This manuscript is based on part of the data collected in this large study. It therefore deals mainly with data from doctorate holders who graduated in São Paulo State, which actually represents a significant share of doctorate holders who graduated in Brazil.

#### **3.1. Data collection**

The data collection strategy used in the evaluation study consisted mainly of an online questionnaire completed by individuals who applied for one of the three scholarships programs offered by FAPESP in the period 1995-2009. This includes the group who were awarded scholarships as well as those who were rejected.

The questionnaire was quite extensive, but the items most pertinent to the present manuscript are information about doctoral education (location, period, and field of

study), and information about their professional trajectory, including employment sector and region, salaries and dedication to teaching and research activities.

The questionnaire was pre-filled with information from each respondent's Lattes Curriculum to facilitate completion and boost the response rate. The Lattes platform is a government-maintained open-data resource containing CVs and other information about researchers' careers throughout Brazil, with a web interface used by virtually all researchers nationwide.

The questionnaire was posted on a specific website for 45 days in February and March 2012. Individuals were invited to complete the personalized questionnaire by email, using contact information available through FAPESP. A total of 57,490 emails were sent, of which 39,765 were successfully delivered.

### **3.2. Sample and data treatment**

The response rate (based invitations successfully delivered) was 22%, resulting in 8,682 complete questionnaires.<sup>3</sup> From this total, 4,134 questionnaires were answered by individuals who had completed their doctoral education. Thus, the study comprises data from PhDs who concluded their doctoral training in or before 2012 and applied for one or more of the FAPESP scholarship programs between 1995 and 2009, regardless of whether this was awarded or not. It should be highlighted that there are some missing values for some of the variables analyzed: this is why the sample size varies in the 'Findings and Discussion' section.

It is important to note that the evaluation study was not conceived as an exhaustive analysis of the professional trajectory of doctorate holders in Brazil. Notwithstanding, it collected a detailed and meaningful quantity of data on variables that provide valuable information about the Brazilian case.

Two additional comments are worth mentioning, in order to better understand the sample and the corresponding data used in this manuscript. Firstly, São Paulo State – one of the 27 Brazilian States – produces almost 50% of graduated PhDs in Brazil. This State is also home to 21.7% of the Brazilian population, and provides circa 33% of its Gross Domestic Product and more than 50% of its scientific production. Secondly, FAPESP has a strong reputation among the national scientific community, particularly due to its rigorous peer review system. This means that those who normally apply to FAPESP have high academic standards and research potential. Thus, data gathered from this group sheds light on issues not yet discussed in the literature, contributing to a broader understanding of the Brazilian case and its differences from other countries.

As already expected considering the study design, the vast majority of doctorate holders from the sample (97.5%) completed their doctoral studies in São Paulo State, with 1.8% in other countries and 0.6% in other States of the country.

In order to answer the main research questions of the manuscript, the collected data about doctorate holders was analyzed in respect of their professional trajectory, including labor market aspects (employment sector, region and dedication to teaching) and research activities and market value of PhDs (wages and premiums). The analysis was compared to general trends from similar studies of other countries, and also to a previous study about PhDs in Brazil (CGEE, 2010) regarded as the main source of data of this kind in the country.

Although it is possible to draw general conclusions from the aggregated data, it is important to distinguish between behaviors among distinct fields of study and time

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<sup>3</sup> By 'complete responses' is understood questionnaires with all required information about undergraduate and graduate education.

period since graduation. As discussed above, the existing literature shows relevant differences considering these variables.

The distribution of the sample according to the main field of study of doctorate holders is shown in Figure 1, in terms of both the number of PhDs and the accumulated share in the sample.

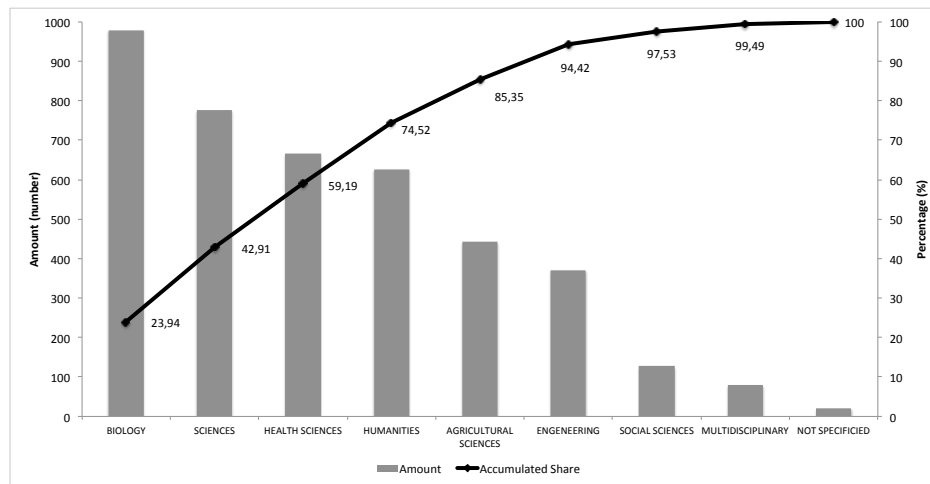


Figure 1: Distribution of the sample by knowledge fields (number and %)

In addition, the distribution of the sample considering time since graduation is presented in Table 1.

Table 1: Distribution of the sample by time period since doctorate completion (number and %)

	Time interval	Amount	Percentage
Doctorate holders with <b>more than ten years</b> since graduation	<2003	494	14%
Doctorate holders with <b>more than five and less than ten years</b> since graduation	2003-2007	1470	41%
Early career doctorate holders ( <b>less than five years</b> since graduation)	> 2007	1636	45%
		3600	100%

## 4. Findings and Discussion

### 4.1. Labor market

More than 52% of doctorate holders from the sample declared they did not have formal jobs in 2012. 37.1% of the whole sample declared holding some sort of post-doctoral position. It is worth noting that a post-doc position in Brazil may or may not include pecuniary earnings (scholarships or other types of payments), but it is never classified as a formal job.

This finding reveals an important concern regarding the mismatch between the supply and demand of highly qualified human resources in the country, since the Brazilian unemployment rate in 2012 was 5.5%<sup>4</sup>, almost one tenth of the rate found for doctoral graduates (including those that declared being in post-doc activities). The unemployment rate for greater São Paulo in the same year was practically the same (5.2%).

A study by CGEE (2010) which gathered data from doctorate holders who finished their PhDs between 1996 and 2006 showed an unemployment rate of almost 30% (the data

<sup>4</sup> Information from monthly Employment Survey (PME) from Brazilian Institute of Geography and Statistics (IBGE).



gathering took place in 2008). The difference between the two studies is probably due to the different samples (the CGEE study dealt with nationwide data while ours was for Sao Paulo's State alone), and different periods covered (ours goes up to 2012, i.e. four years longer than the CGEE one, a period in which the number of PhDs increased by more than 18% in the country). From any perspective, the rates of unemployment in both studies are far higher than in found in other countries.

Many studies have shown an unemployment rate of around 1% for doctorate holders in other countries. Auriol et al. (2012) in a study covering 20 countries including both developed and less developed countries found an average rate of 1.2%. The American survey of earned doctorates (NSF, 2013a) showed an unemployment rate of about 2% in 2010. Even considering the more recent studies showing an increasing mismatch between supply and demand of doctorate holders (Taylor, 2011; Cyranoski et al., 2011, Neumann and Tan, 2011), the figures are far lower than those found in the Brazilian case. One does not find a phenomenon of 30% or more unemployment, suggesting a problem that needs to be analyzed and tackled.

Furthermore, in spite of being one of the main tracks followed by PhDs around the world, the elevated rate of post-doctoral positions in the sample reinforces this mismatch. In Brazil, post-doc does not denote a particular kind of job contract with host institutions, as is typically the case in many countries. It is just a temporary connection, which can help in the securing of tenure-track professor jobs, but by no means guarantees them.

More than 70% of those individuals in the sample that held post-doctoral positions in 2012 gave as their main motivation the opportunity to continue developing research activities. Hence, a post-doc can be seen as a provisional solution that a great number of PhDs turn to while waiting for a research job opportunity to arise.

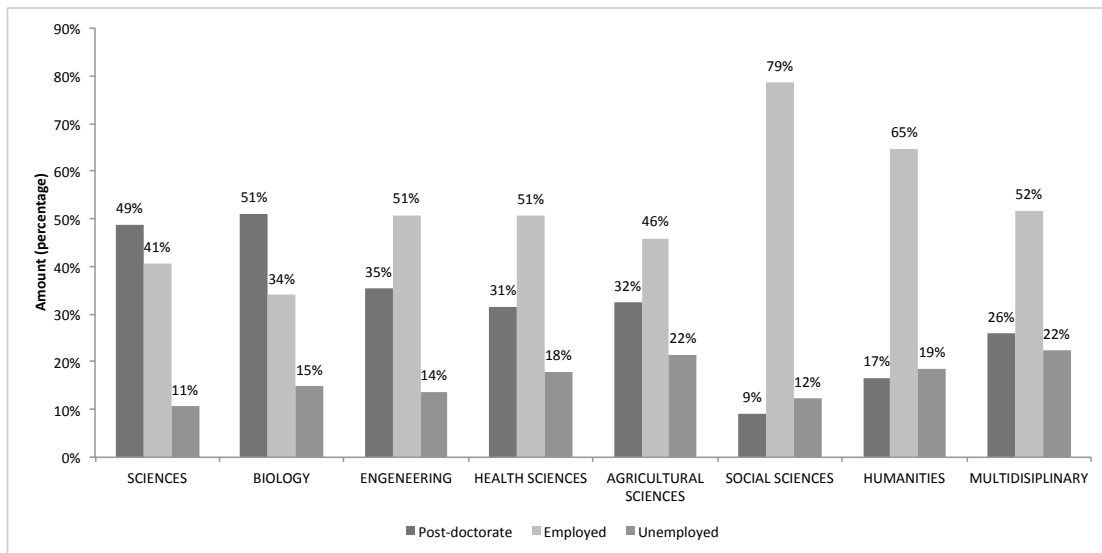


Figure 2: Employment status among knowledge fields

Variations in the employment status of doctorate holders across fields of study (Figure 2) indicate different situations. Sciences (physics, chemistry, mathematics and earth sciences) and Biology fields have similar profiles, in that post-docs are quite common (about 50% of PhDs from the sample in these fields in 2012). A post-doc is considered a particularly important prerequisite in these fields for achieving permanent academic positions, and it is a “natural” path for those who have not obtained a job position and want to pursue academic activity.

Engineering, health sciences, agricultural sciences, and multidisciplinary fields are similar to each other in terms of formal unemployment rates. Social sciences and humanities comprise another group, inasmuch as post-doctoral positions are not common (half or less of the sample's average), and employment rates are higher (almost 80% in social sciences). This is in accordance with Brazilian data from 2008 (CGEE, 2010).

Employed PhDs from the sample were mostly working in six economic sectors in 2012<sup>5</sup>: educational services (68.6%), professional, scientific and technical services, which comprises R&D and consultancy (12.4%), health care and social services (5%), agriculture (3.8%), public administration (1.3%), and manufacturing (1.1%).

Previous findings from CGEE (2010) on the general employment situation of Brazilian PhDs are similar to our own. In 2008, the most important employers for PhDs who graduated since 1996 were educational services (76.8%), public administration (11.1%), professional, scientific and technical services (3.8%), health care and social services (3%) and manufacturing (1.4%). The difference in the share of public administration between data presented here and the one from CGEE (2010) is due to the large number of PhDs with jobs in federal public administration that are located mainly in Brazil's central region and also Rio de Janeiro State (and not in São Paulo State).

A comparison of those who graduated in 1996 with those who graduated in 2006 within the same study (CGEE, 2010) also shows that the education sector has been losing ground as an employment destination. The same conclusion can be drawn when comparing the CGEE study with our own, since the education sector's share decreased when analyzing the sample by time period since doctorate completion. This trend – associated with the increase in some other sectors – is shown in Table 2.

In the case of the manufacturing sector, it is worth noticing that while the overall share is modest, the increase is significant over time.

Table 2: Share of PhD employment across economic sectors, by time period since doctorate completion

	<2003	2003-2007	>2007	Trend Test p-value*
Educational services	69.6	70.0	66.7	0.082
Professional, scientific and technical services	13.9	12.1	11.7	0.218
Health care & social assistance	2.6	4.7	7.3	<0.001
Agriculture	4.4	4.5	3.2	0.077
Manufacturing	0.4	1.1	1.4	0.092
Public administration	1.5	1.5	1.4	0.971

\*Linear tests performed by logistic regression models

In terms of the prevalence of doctorate holders' jobs in the academic sector and the recent increase of other sectors' share, these results also accord with worldwide patterns found in the existing literature. Nevertheless, data from the sample indicates that the share of PhD employment in the manufacturing sector is about 14 times less than the share of doctorate holders' employment in business enterprises in other

<sup>5</sup> This classification is based on the National Classification of Economic Activities (CNAE) of the Brazilian Institute of Geography and Statistics (IBGE).

countries (Auriol et al., 2012). In addition, very few employed PhDs declared themselves as entrepreneurs (2.8%), reinforcing the previous evidence.

The evidence presented here suggests that the impacts of PhDs in Brazil are mainly in teaching and learning effects related to academic jobs. There are minimal impacts on creating a generation of new or improved products processes and services in the country, or the generation of R&D environments within the firms. Although it is possible to argue that knowledge developed in universities or research organizations by this critical mass of PhDs could be transferred to industry and/or the services sector, it is well known that some absorptive capacity is needed to effectively use this knowledge in order to foster innovation.

What aggregate data from Brazil shows is that the development of this absorptive capacity towards innovation is very much limited. According to OECD (2012), Brazilian business R&D expenditure was in the middle range below the OECD median in 2011. The Brazilian innovation survey (IBGE, 2013) supplements this finding, since 36% of firms declared some kind of technological innovation in the period 2009-2011, but less than 10% these developed products or processes new to the country. About 5% of those firms had some kind of internal R&D efforts; the average R&D expenditure was less than 1% of net sales revenues and about 10% of individuals working in R&D activities had some kind of post-graduate degree (master's or PhD). In addition, the low shares of PhDs in other sectors such as health care and public administration reinforce the general argument of weak demand for highly qualified researchers in the country.

The relationships between field of study and sector of employment also show some interesting although perhaps expected results. 76% of those working in the agriculture sector graduated in agricultural related disciplines; 75% of those working in manufacturing graduated in sciences and engineering; 92% of those working in health care and social services graduated in biology and health sciences. PhDs who graduated in social sciences are poorly involved in professional, scientific and technical services, and even in the educational services sector.

Most of the employed PhDs declared involvement in both teaching and research activities (46.6%), just research (19.6%) or just teaching (9.3%), which means that almost 75% of these highly qualified human resources are utilizing 'traditional' PhD skills in their jobs. Furthermore, a significant share of PhDs were working in public institutions (63.6%).

Table 3 correlates the most represented economic sectors with the type of activities pursued by doctorate holders.

Table 3: Economic sectors and dedication to teaching and research (number and percentage)

	Teaching and Research	Research	Teaching	Not dedicated to Teaching and Research	Total
Educational services	461 77%	22 4%	85 14%	27 5%	595 100%
Professional, scientific and technical services	34 30%	51 45%	4 4%	23 21%	112 100%
Health care & social assistance	25 30%	14 17%	3 3%	42 50%	84 100%
Agriculture	0	33	1	5	39

	0%	85%	2%	13%	100%
Public administration	4 23%	2 12%	1 6%	10 59%	17 100%
Manufacturing	0 0%	13 69%	1 5%	5 26%	19 100%

The previously described results along with those in Table 3 show other important and complementary features that help to understand the professional careers of doctoral graduates in the country. In the Brazilian educational services sector, there is a historical divide between public universities, seen as centres of excellence for both teaching and research, and the private ones, which despite accounting for around 70% of undergraduate enrolments generally do not perform research, having relatively few graduate programs and quite a restricted number of employed PhDs (Balbachevsky, 2004).

Moreover, careers in public higher education institutions are guided by very structured careers plans: faculties are selected and hired by public tender; they are generally supposed to have full-time contracts and to perform teaching, research and 'third mission' activities simultaneously; space in institutions for researchers (not involved in teaching) are very restricted. On the other hand, private higher education institutions have much more freedom to establish part-time contracts and to hire professionals solely for teaching, without any stimulus or support for them to perform research activities.

Another Brazilian feature is the important role of public research organizations in graduate education, since quite a significant number of these institutions also provide master's and doctoral education in their fields of expertise. As can be seen, almost 30% of doctorate holders in professional, scientific and technical services (which is mainly constituted by public research organizations) also dedicate themselves to teaching along with their research activities.

In health care and social services, and also public administration, doctorate holders are mostly not involved in teaching and research, which could indicate some diversification of the traditional PhD skills into non-academic sectors. Nevertheless, the most probable explanation is that a large number of posts in these areas are obtained by public tender, which traditionally values a doctoral degree as a criterion for general classification of candidates, but does not necessarily make use of doctoral skills in everyday activities. In addition, it is worth noting that public administration also values the doctoral degree as a means of professional advancement and related rewards.

Although also limited by the number of observations, the agriculture sector can be distinguished in terms of research, which accords with the importance of the sector in the Brazilian export market. In the manufacturing sector, although low in total and relative numbers, PhDs are mostly involved in R&D activities.

The underlying conclusion is that PhD skills are most obviously valued in jobs that requires teaching and research activities. Doctoral education to a large extent thus fulfils a self-reproductive function for the academic profession. PhDs are somewhat undervalued in other sectors, perhaps as a result of demand-supply mismatch, or more probably because there is little demand for PhDs with either traditional or new and diversified skills in the country.

The other important feature of the Brazilian PhD labor market is the aforementioned regional research concentration in the country. The majority of PhDs from the sample were working in São Paulo State (69.4%) in 2012, which was expected given that they completed their doctoral training there. Considering that 97.5% graduated in the State, a

28% rate of migration can be derived. Data from CGEE (2010) suggested a similar trend, with 22% of those who graduated in São Paulo between 1996 and 2006 working in other regions of the country in 2008. São Paulo was and still is the main research and economic center of Brazil, although it has been recently losing ground to other regions of the country. This is also a matter of policy importance, since regional decentralization can certainly contribute to boosting demand for PhDs within the country.

#### 4.2. Market value

About 50% of doctorate holders from the sample had in 2012 a wage of nine to fifteen times the national minimal wage, which corresponded approximately to US\$ 2,800 to US\$ 4,800 per month (Figure 3). The average monthly earnings of the employed PhDs in 2012 was US\$ 3,700. Previous data from CGEE (2010) gave an average amount of US\$ 4,444 in 2008 of those graduated from 1996 to 2006<sup>6</sup>, which can either suggest some loss between 2008 and 2012 or just an ad hoc result of different samples and time periods as mentioned above.

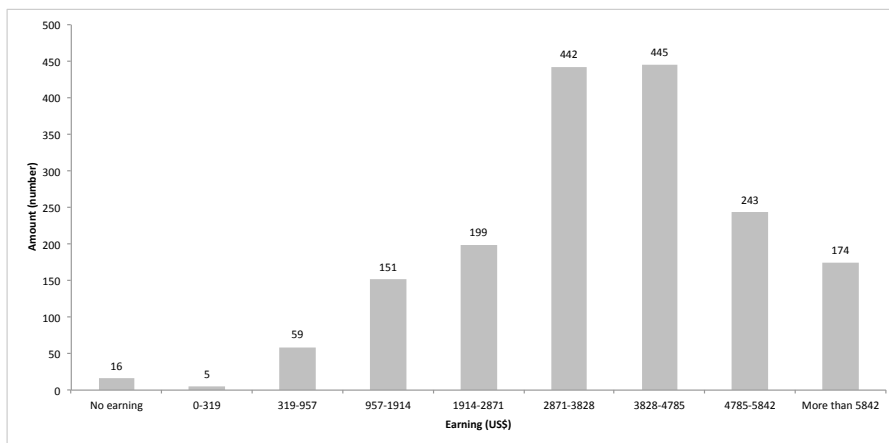


Figure 3: Distribution of doctorate holders' earnings in 2012

As predicted, there is some variation when considering time period since doctorate completion (Figure 4). Around 41% of those with more than 10 years since graduation earned over US\$ 4,785 per month, while for those with 5 to 10 years since graduation the percentage is 22%, and 16% for early-careers. However the difference among the curves is not so marked, which means that PhD wage progression in Brazil is quite restricted. A feasible explanation for this is that the majority of doctoral graduates' jobs are in public higher education and research institutions, where wages vary in accordance with an established career plan. The pay scales are adjusted from time to time, with no space for negotiation for higher skills or even outstanding performance, although there are pecuniary compensations related to service time and administrative positions. Considering, for instance, a faculty career in Brazilian federal higher education institutions in 2012, the difference between the first level (equivalent to a lecturer) and the last level (equivalent to professor) was just 38% (not considering the additional pecuniary compensations mentioned above). In São Paulo higher education institutions, for the same year, the difference was even less – about 30% (again, not considering the additional pecuniary compensations).

<sup>6</sup> Conversions made using rates from 2012 (US\$1=R\$1.95) and National Broad Consumer Price Index (IPCA) to update values.

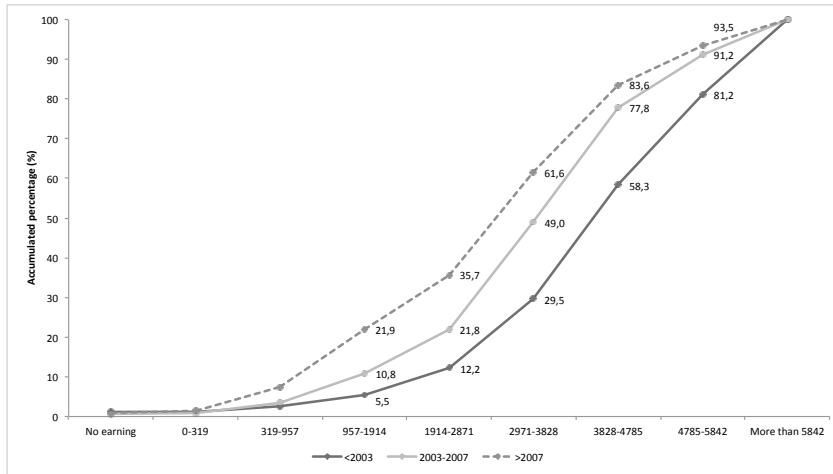


Figure 4: Accumulated doctorate holders' earnings in 2012 (US\$1=R\$1,95) by time period since doctorate completion

There were no significant differences in PhD earnings between different fields of study, according to the 2012 data. For sciences, engineering and social sciences, wages are 10%, 13% and 11% higher than average respectively. For other fields, they are lower than average, in particular for biology (9% less). Similar results were found in CGEE (2010), with engineering and social sciences graduates earning 8% and 30% more respectively.

The average wage a Brazilian employee with higher education in 2012 was US\$ 2,265, which equates to a PhD wage premium of around 64%.<sup>7</sup> This is a very elevated rate compared with data from USA and UK in 2003-2011 – almost 35% in the first case and 15% in the second (OECD, 2013). When compared to the national average wage of employees with no higher education, the premium for a PhD graduate rises to 428%.<sup>8</sup>

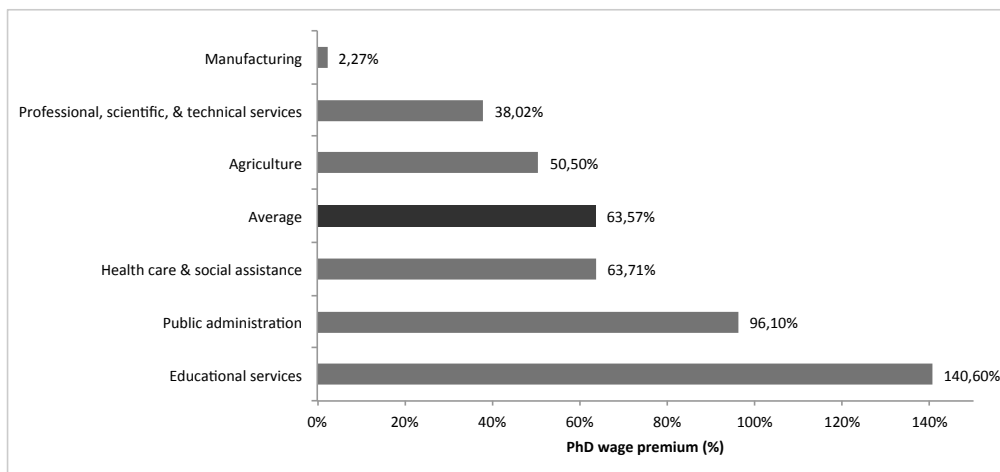


Figure 5: PhD wage premium among economic sectors, in relation to employees with higher education

Figure 5 depicts the variation in the PhD wage premium among different economic sectors in Brazil. It is quite important to note that while in public administration and educational services the pecuniary returns from the possession of a PhD are higher than average in the country, in other significant sectors such as manufacturing the premium can be very low if not insignificant.

<sup>7</sup> Data from Central Register of Enterprises - IBGE.

<sup>8</sup> Ibidem.

The most noteworthy finding is the “ineffectiveness” (from the individual’s point of view) of holding a doctoral degree in industrial employment. This can be explained by the low rates of investment in R&D activities by companies, but also by the fact that the research performed in industry does not require PhDs (although it often requires further technical – and commonly management – training of their graduate employees). This raises an important question about the demand-supply mismatch, which is not only large in general, but particularly so in the industrial sector.

On the other hand, in several other sectors the possession of a PhD qualification in Brazil brings a significant premium. In addition, wage increases along PhDs’ career paths are very limited, which has much to do with the features of faculty careers in public higher education institutions in the country, but also with the valuation problem of doctoral graduates’ skills discussed above.

## **5. Conclusion**

To return to the initial questions set at the start of this chapter, it is possible to conclude that doctorate holders in Brazil are not being adequately absorbed by the labor market, which imposes important constraints in terms of generating economic and social impacts.

In summary, comparing the results presented in the previous sections to similar studies of developed countries, one can find analogous results: disequilibrium between PhDs’ supply and demand; prevalence of doctorate holders’ employment in higher education (although with a decreasing trend in recent years); emergence of employment of doctorate holders in other sectors; PhD premium wages and variances among fields of study and time period since PhD completion. Nevertheless, the imbalances are much more evident in the Brazilian situation. The supply-demand mismatch is much higher than in other countries, while the share of PhD employment in non-academic sectors is still much lower, particularly in the manufacturing sector. Premium wages are reasonable in Brazil, but overall earnings are still below expected considering the qualifications of doctorate holders, and they increase relatively little over the course of an individual’s career.

What does this mean in terms of impact of PhD holders in the country? On the one hand, Brazil has achieved great success in improving its doctoral programs and creating new PhDs at an unprecedented rate. This had obviously increased the ‘pool of knowledge’ in the country, a fact reinforced by recent achievements from Brazilian scientific production. Analysis of the Scopus database indicates that the scientific production of the country increased 3.5 times from 2001 to 2011, resulting in Brazil moving up to 13<sup>th</sup> place for quantity and 17<sup>th</sup> place for citations. In the same year, for scientific production indexed by Web of Science, Brazil held the 15<sup>th</sup> and 20<sup>th</sup> positions respectively. This is quite a good performance and has much to do with supporting research of PhD holders, but also fostering international collaborations and the quality of doctoral programs based on the quality of faculties and students’ publications.

The teaching and learning effects of doctoral education can also be estimated, although it is difficult to find objective measures for doing so. The large number of PhDs absorbed by higher education and research organizations actually involved with teaching (both in undergraduate and graduate programs) is in itself evidence of this kind of effect. Private returns can also be addressed as recognizable impacts, since wage premiums associated with having doctoral degrees are huge in the country.

In terms of creating innovative environments and fostering innovation in the country, impacts are very limited, which means that doctoral education in Brazil is being utilized much more by the academic profession than for other activities. While to some extent this may be the result of the lack of industry-oriented skills of PhDs, the main reason is

the innovative profile of Brazilian firms. R&D efforts are limited, and most innovations that do take place are only “innovative” at the level of the firm; few are new to Brazil, and even less are new to the world as a whole.

The main implication of this analysis is the necessity of promoting a more convergent path between doctoral education policies and research and innovation policies. In spite of being a common characteristic among many countries, the unbalance between PhD supply and demand is perhaps much more evident in emerging countries like Brazil, precisely because the gap between the creation of research capabilities and the creation of research-based job positions in non-academic sectors is wider than in developed economies.

In the Brazilian case - as is the case in many less developed countries - this sort of unbalance might also be the result of a historical trajectory where policies for training high level students were much more effective than policies designed to absorb these trained personnel by fostering innovation and/or adequate links between public policy formulation and evaluation and research.

Brazil is not a case of a country that has overdeveloped its academic sector, but rather a country that has not developed an STI system in a more balanced way. The same country that today is producing almost 3% of the total scientific publications in the Web of Science is filing less than 0.1% of patents in the USPTO. Even considering these are quite narrow indicators, they do reveal characteristics from the Brazilian system of science, technology and innovation that are wholly consistent with the results presented in this chapter.

This does not mean that investments in PhDs programs should be cut to equalize the situation. Nor should new job positions specifically for PhDs be artificially created if their competences will not be used effectively in daily tasks. To reduce the strong imbalance evident in Brazil and in other less developed countries is a matter of rethinking the whole STI system and starting to stimulate true demand for high-qualified individuals.

In this perspective, one important recommendation for the near future would be the promotion of convergence among policies in a way that allows them to co-evolve in terms of their synergic and integrated effect. As pointed out by Flanagan et al. (2011) there is a clear trend in many countries towards the promotion of a mix of policies. When a policy mix is developed as part of a coherent strategy, economies of scale and scope are more likely to emerge than when these policies are not designed and implemented in an integrated way.

Given the evidence presented here about the Brazilian case, it is not enough to rethink doctoral education in terms of approaches and skills. It is necessary to act on the demand side, which means developing and implementing effective innovation policies, but also changing the actual parameters of public sector careers, mainly in higher education and research organizations, including functional differentiation and hiring flexibility parameters. In addition, considering the particularities of the Brazilian case, there are two complementary policies that have to be added to the policy mix in order to promote the real co-evolution of human capital formation and institutional research capacity building. These are research decentralization in the country, which is already a target of public policies in Brazil, and the quality of private higher education institutions, which was a priority in the past but not at present. Only an effective policy mix could support new possibilities for doctorate holders in the country, since the Brazilian problem is not so much the lack of skills constraining economic growth, but rather the lack of incentives and effective ways to use these skills.



Although the use of regional concentrated data could be considered a limitation in this study, the sampling of PhDs who graduated in São Paulo State and applied for scholarships in FAPESP means that the sample comprises part of the elite of PhDs in Brazil. Of course, other particularities could be found in a more comprehensive sample of Brazilian PhDs, but the overall conclusions would be nearly the same, as shown by the evidence of CGEE (2010).

Finally, despite the evidence presented here about the supply-demand mismatch of PhDs in Brazil, further investigation is still needed on this subject. Implementing systematic studies to map doctoral graduates' careers in Brazil and also expanding investigations into the incentives in different economic sectors for hiring PhDs would seem to be a first step in this direction.

## References

AURIOL, L. Careers of Doctorate Holders: employment and mobility patterns. STI Working Paper 2010/4. Statistical Analysis of Science, Technology and Industry, OECD, 2010.

AURIOL, L.; MISU, M.; FREEMAN, R. Doctoral graduates in times of economic downturn: labour market participation and mobility. Working Party of National Experts on Science and Technology Indicators. Directorate for Science, Technology and Industry - Committee for Scientific and Technological Policy, OECD, 2012.

BALBACHEVSKY, E. Graduate Education: emerging challenges to a successful policy. In: Brock, C.; Schwartzman, S. (Eds). *The Challenges of Education in Brazil*. Oxford Studies in Comparative Education. Oxford, UK: Triangle Journals, Ltd., 2004. pp. 209-228.

BASIL, M.D.; BASIL, D.Z. The marketing market: A study of PhD supply, demand, hiring institutions, and job candidates. *Journal of Business Research*, 59. p. 516 – 523, 2006.

CARNEY, J.; CHAWLA, D.; WILEY, A.; YOUNG, D. Evaluation of the Initial Impacts of the National Science Foundation's Integrative Graduate Education And Research Traineeship Program. Final Report, 2006.

CASEY, B.H. The economic contribution of PhDs. *Journal of Higher Education, Policy and Management*, 31(3). p. 219-227, 2009.

CGEE. *Ciência, tecnologia e inovação para o desenvolvimento das Regiões Norte e Nordeste do Brasil: Novos desafios para a política nacional de CT&I*. Brasília: Centro de Gestão e Estudos Estratégicos, 2011.

CGEE. *Doutores 2010: estudos da demografia da base técnico-científica brasileira*. Brasília, DF: Centro de Gestão e Estudos Estratégicos, 2010.

CHANG, W., MILAN, L.M. International Mobility and Employment Characteristics among Recent Recipients of U.S. Doctorates. Infobrief – NCSES. NSF 13-300, 2012.

COHEN, W.M.; LEVINTHAL, D.A. Innovation and Learning: The Two Faces of R &D. *The Economic Journal*, 99(397), p. 569-596, 1989.

CONNOR, H.; BROWN, R. *The Value of Graduates and Postgraduates*. Council for Industry and Higher Education, 2009.

CRUZ-CASTRO, L.; SANZ-MENÉNDEZ, L. Mobility versus job stability: Assessing tenure and productivity outcomes. *Research Policy*, 39, p. 27-38, 2010.

CRUZ-CASTRO, L.; SANZ-MENÉNDEZ, L. The employment of PhDs in firms: trajectories, mobility and innovation. *Research Evaluation*, 14(1), p. 57-69, 2005.

CYRANOSKI, D.; GILBERT, N.; LEDFORD, H.; NAYAR, A.; YAHIA, M. The PhD Factory: The world is producing more PhDs than ever before, Is it time to stop? *Nature*, 472(21). p. 276-279, 2011.

ENDERS, J. Border crossings: Research training, knowledge dissemination and the transformation of academic work. *Higher Education*, 49, 119–133, 2005.

ENDERS, J. Serving many masters: The PhD on the labour market, the everlasting need of inequality, and the premature death of Humboldt. *Higher Education*, 44, 493–517, 2002.

FLYNN, C.B.; FIELD, H.S.; BEDEIAN, A.G. “Life could be a dream”: what US-based management PhD students desire in an initial academic appointment. *Career Development International*, 16(4). p. 316-341, 2011.

GABINETE DE PLANEAMENTO, ESTRATÉGIA, AVALIAÇÃO E RELAÇÕES INTERNACIONAIS (GPEARI)/ MINISTERIO DA CIENCIA, TECNOLOGIA E ENSINO SUPERIOR. (2011). Fluxos e situação profissional dos doutorados em Portugal – 2009.

GARCIA-QUEVEDO, J.; MAS-VERDÚ, F.; POLO-OTERO, J. Which firms want PhDs? An analysis of the determinants of the demand. *High Educ*, 63, p. 607–620, 2012.

GEMME, B.; GINGRAS, Y. Academic careers for graduate students: a strong attractor in a changed environment. *High Educ*, 63. p. 667–683, 2012.

GIBBONS, M, C LIMOGES, H NOWOTNY, S SCHWARTZMAN, P SCOTT AND M TROW. The new production of knowledge: The dynamics of science and research in contemporary societies. London: SAGE, 1994.

GRADUATE CAREERS AUSTRALIA. Australian Graduate Survey 2012: A Report of the Conduct of the 2012 Australian Graduate Survey, 2013.

HALSE, C.; MOWBRAY, S. The impact of the doctorate. *Studies in Higher Education*, 36(5), p. 513-525, 2011.

HEITOR, M.; HORTA, H.; MENDONÇA, J. Developing human capital and research capacity: Science policies promoting brain gain. *Technological Forecasting & Social Change*, 82. p. 6–22, 2014.

IBGE. Pesquisa de Inovação Tecnológica 2011. Rio de Janeiro: IBGE, 2013.

INNES, P.; FEENEY, D. Career Paths of AHRC funded PhD Students. Final Report, 2012.

JOHNSON, S.; WILLIAMS, G. Evaluating the Impact of Social Scientists. Final Report to Economic and Social Research Council, UK, 2011.

KITAGAWA, F. How to Capture the Impact of the Engineering Doctorate (EngD) programme to Industry? – Conceptual and Methodological issues related to Measuring the Performance of the Triple Helix Approach. Triple Helix International Conference XI, 8-10 July, London, 2013.

KOBAYASHI, S. The Ph.D. as a Professional: Current Status and Issues concerning the Early Careers of Doctorate Holders. *Japan Labor Review*, 8(4), 46-66, 2011.

KUMAR, V.; KUMAR, N.; SAPNANARULA. Plethora of Indian Education: Are We Following the Development Path? *Liceo Journal of Higher Education Research*, 7(1), 39-46, 2012.

LEE, H.; MIOZZO, M.; LAREDO, P. Career patterns and competences of PhDs in science and engineering in the knowledge economy: The case of graduates from a UK research-based university. *Research Policy*, 39, p. 869–881, 2010.

LEITCH, S. Prosperity for all in the global economy - world class skills, Final Report, London: HMSO, 2006.

- LI, P.S.; LI, L.; ZONG, L. Postgraduate Educational Aspirations and Policy Implications: A case study of university students in western China. *Journal of Higher Education Policy and Management*, 29(2), pp. 143–158, 2007.
- LUCHILO, L. *Formación de posgrado en América Latina: políticas de apoyo resultados e impactos*. 1a ed. Buenos Aires: Eudeba, 2010.
- MANGEMATIN, V. PhD job market: professional trajectories and incentives during the PhD. *Research Policy*, 29. p. 741-756, 2000.
- MARCHELLI, P.S. Formação de doutores no Brasil e no mundo: algumas comparações. *RBPG*, 2(3), 7-29, 2005.
- MCCOOK, A. Rethinking PhDs. *Nature*, 472, 280-281, 2011.
- NEUMANN, R.; TAN, K.K. From PhD to initial employment: the doctorate in a knowledge economy. *Studies in Higher Education*, 36(5), p. 601–614, 2011.
- NG, S.F.; MUHD, N.M.N., RAHMAN, K.A.; ISMAIL, N. Influential factors to pursue doctorate degree in Malaysia. *Procedia Social and Behavioral Sciences*, 15, 2028–2032, 2011.
- NOWOTNY, H.; SCOTT, P.; GIBBONS, M. *Rethinking science: knowledge in an age of uncertainty*. Cambridge: Polity Press, 2001.
- NSF. Survey of Doctorate Recipients – SDR, 2013a. Available in <<http://www.nsf.gov/statistics/srvydoctorates/>> .
- NSF. Survey of Earned Doctorates – SED, 2013b. Available in <<http://www.nsf.gov/statistics/srvydoctoratework/>>.
- OECD. *Transferable Skills Training for Researchers: Supporting Career Development and Research*, OECD, Paris, 2012.
- OECD. *OECD Science, Technology and Industry Outlook 2011*, 2012.
- OECD. *Key findings of the oecd-knowinno project on the careers of doctorate holders*, 2013.
- ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)/UNESCO, EUROSTAT. *Mapping careers and mobility of doctorate holders: draft guidelines, model questionnaire and indicators: the OCDE / UNESCO Institute for Statistics Eurostat Careers of Doctorate Holders (CDH) Project*, STI Working Paper 2007/6. Paris: OCDE, 2007.
- PAVITT, K. What makes basic research economic useful? *Research Policy*, 20, p. 109-119, 1991.
- RADDON, A.; SUNG, J. *The Career Choices and Impact of PhD Graduates in the UK: A Synthesis Review*. ESRC; RCUK, 2009.
- ROACH, M.; SAUERMAN, H. A taste for science? PhD scientists' academic orientation and self-selection into research careers in industry. *Research Policy* 39, p. 422–434, 2010.
- SALTER, A.J.; MARTIN, B.R. The economic benefits of publicly funded basic research: a critical review. *Research Policy*, 30, p. 509-532, 2001.
- TAYLOR, M. Reform the PhD system or close it down. *Nature*, 472, p. 261, 2011.
- TREMBLAY, K. Academic Mobility and Immigration. *Journal of Studies in International Education*, 9(3), p. 196-228, 2005.
- VELLOSO, J. *Mestres e Doutores no País: destinos profissionais e políticas de pós-graduação*. *Cadernos de Pesquisa*, 34(123), p. 583-611, 2004.

VITAE. What do researchers do? Doctoral graduate destinations and impact three years on 2010. The Careers Research and Advisory Centre; RCUK, 2010.

YANG, R. Up and coming? Doctoral education in China. *Australian Universities' Review*, 54(1), 64-71, 2012.

ZUSMAN, A. Challenges Facing Higher Education in the Twenty-First Century. In: Altbach, P.G.; Berdahl, R.O.; Gumport, P.J. (Eds). *American Higher Education in the Twenty-first Century: Social, Political, and Economic Challenges*. 2<sup>nd</sup> Edition. Baltimore: The Johns Hopkins University Press, 2005.