

# Evaluation of the Impact of Open Innovation and Acceleration Programs on Research and Development Performed by Universities

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**Abstract.** Commonly-known for their sophisticated and robust results, and some lack of time-to-market orientation, the universities are reviewing their roles to be more competitive in the innovation ecosystems. The actual context is large growing of acceleration programs to promote Open Innovation in startups, as well as traditional corporations, interested in the development of innovation across organisational boundaries. Although recent studies emphasise that startups developed or supported by universities have more expectations of success than non-academic startups, the movement of acceleration programs with an emphasis on open innovation is not always connected to universities and supported for research and development. This fact indicates that there are opportunities to encourage the work of universities with companies and other actors for the development of market-oriented proposals and innovative solutions that cover different fields of knowledge through transdisciplinary research. This study has as main objective to identify practices and impacts of acceleration programs for open innovation and its relationship with Research and Development in universities. This study is conducted in two phases in order to analyse the impacts: the first is a systematic review of the literature to identify state of the art of the studied themes in a combined manner. The second phase of the article consists in study two application cases of acceleration programs at the Pontifical Catholic University of Paraná. The work aims to analyse the impacts of the open innovation and acceleration programs found in the literature and in the case study in order to identify opportunities for improvement for the programs of acceleration of open innovation which universities propose or participate. The expected result is to provide subsidies for universities to increase their participation and contribution in programs, to accelerate innovation and open innovation, supported by transdisciplinary and excellent research.

**Keywords.** Open innovation, research and development, university, accelerator programs.

## Introduction

Among other stakeholders, manufacturing industries of different types are interested in sustainable innovation and depend on universities to satisfy the demand for qualified labour [4]. In order to satisfy the expectations of industries and also of society in general, universities are increasingly relying on transdisciplinary training and collaboration with different actors, such as the industry itself and the government to deliver innovative solutions [4] and [5].

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The arise of division in innovation labour which, universities specialise in research, small start-ups convert promising recent findings into inventions; and more substantial and more established firms specialise in product development and commercialisation [6]. Such fragmentation could lead to a player specialisation, therefore decreasing innovation diversity, competition and the societal impact of Universities' R&D [6]. However, this scenario is uncertain as long as a shift in the role of universities from education providers to scientific knowledge and technology producers in the current knowledge-driven economy [7]. In this context, in which companies and universities are collaborating through different types of work, new university roles are required [8]. The authors of the present work started studying the role of the university [9], especially the contributions of research, development and its impact on innovation.

In the relations between university-industry-government, there are some possibilities of knowledge transfer to generate innovation, among these modalities, three types of programs are studied in a combined way in this work: open innovation (OI) and acceleration programs (AP) in research and development (R&D).

According to the literature review carried out below, recent research on the theme development of ecosystems has increased. Many of these studies have been focused on results, methodologies, financial or social aspects, among other theoretical and practical aspects [10], [11] and [12]. However, it is understood that there is an opportunity to study research and development and its relationship with open innovation initiatives and acceleration programs. This study aims to identify the impact of acceleration programs and open innovation programs and their respective contributions to Research and Development at universities. To find the outcomes of acceleration and open innovation programs and their impact on research and development carried out by universities, a systematic literature review of the three topics of interest and analysis of two application cases in Brazil are presented as follows.

## 1. Background

The rise of technologies, sustainability opportunities, cost reduction and user experience, has produced a vast number of initiatives to offer incremental or disruptive innovations in their primary alternative forms: process, products and services, business models [13]. To this purpose, innovation partnerships and the sharing-is-winning model emerge intending to accelerate co-development of sustainable innovation, with the alignment of the entire value chain with consumer-centred innovations as one of its main pillars [11].

Universities play essential and different roles in entrepreneurial ecosystems, can play one of the actors in the innovation network, supporting research and development; as a channel for recruiting entrepreneurs or; as co-working spaces [14] and even more. In this way, the relationship between universities and industry is acquiring significant importance, supported by the knowledge-based economy and obtaining sustainability through knowledge transfer [15] and [16]. Moreover, when the topic specifically mentions knowledge transfer and innovation, there are several adaptations between industry and university for the closeness of work and the guarantee of better results for innovation [11] and [4]. Recently, a new definition of innovation ecosystems was proposed [17], compiling several previous concepts. According to the authors, an innovation ecosystem is the evolving set of actors, ventures, artefacts, organisations and relationships, including complementary services and substitute relationships, essential for the innovative performance of an actor or a population of actors [17]. In addition to the same concept, it can be said that business ecosystems can build a structural dynamic among various partners in the system [18]. These partners are listed as, but not only,

start-ups, venture capital funds, government agencies, research institutions, and others; including the nature and dynamics of connections installed [18] and [20].

One way that innovation ecosystems work is through acceleration programs (AP), which in essence are intensive and limited-time educational programs that, through practical situations, develop teams composed of students, professionals, teachers and researchers, to make them able to grow your ideas on the field. In these programs, start-ups are selected according to predetermined criteria, and their founders receive support and guidance. In this way, their teams/start-ups are able quickly to be exposed to different types of mentors, such as entrepreneurs, angel investors, executives in order to attract resource for their start-ups to reach new levels of business maturity. The programs have a high point of presentation of start-ups to potential investors and other interested parts, called a "demo-day" where each participating start-up defends its project, known as "pitch" [19] and [20].

With the growth of business and university ecosystems, incubators and accelerators have become an integral part of that ecosystem needed to support the growth of new ventures [21]. An accelerator is a generic organisation that plays a crucial role in encouraging entrepreneurship and validating their respective ecosystems of business innovations. These initiatives guarantee a vital position in the development of technological and socio-economic advancement. [20]

Additionally, to the changes that are occurring in the ecosystems, the open innovation concepts are gaining space in the universities-industry relationship. The goal of open innovation is to reorganise innovation processes, taking knowledge flows across organisational boundaries [5], which means that more open sources of external knowledge have been proven to facilitate better results for innovation [22]. It is based on this concept, that every type of company works close to universities, government, suppliers and customers to gather new and unexpected knowledge to develop more innovative products, services and processes. In other words, OI practices can be extended to research and innovation management practice and its interactions with business ecosystems [22] and [23]. The concept of OI, supported by the classic Triple Helix, proposes interactions between university, industry and government as the pillar of innovation. In the Triple Helix concept, universities play an essential role in OI's contribution, as they are an essential supplier of knowledge in Research and Development (R&D) [23]. The practices of OI are now becoming more present in innovation activities in the university, industry and government, which has been shaping new approaches in the way as universities produce R&D, directly impacting the results of the innovation.

In this context, the present work aims to compare qualified literature and practical efforts to produce better results for the entrepreneurial ecosystem. While the university is considered as the main actor, the present work verified the adherence between theoretical studies and research practices, open innovation in an acceleration and development program in the entrepreneurial ecosystem.

## **2. Method**

### *2.1. Systematic Literature Review*

Based on the research methodology previously developed by [25], [26] and [27], a systematic literature review (SLR) was conducted in the present study in order to identify state of the art. A SLR is 'a systematic, explicit and reproducible method for identifying, evaluating and synthesizing the existing body of completed and published work produced by researchers, academics and professionals' [28]. With the analysis of the

research problem, the authors selected three themes which better represented the research: Acceleration Programs (PA), Open Innovation (OI), Research and Development (R&D). Two stages, combining R&D with PA, and R&D with OI and its respective synonyms, were searched, keeping the focus in R&D as a central theme, with the inclusion of keyword University (UNI). These different combinations of keywords and synonyms were consulted in the Scopus and Web of Science (WoS) databases from 2009 - 2019.

The first search using the keywords, their combinations and synonyms found 204 articles, and after the exclusion of duplicates, the result was 161 articles. In the next step, all the articles that satisfied the following criteria were selected: articles in English, from journals with Q1 classification (according to Scimago Journal Rankings), resulting in 90 articles. The last step consisted of reading the title, summary and keywords in order to find only articles precisely related to the research topic, resulting in 16 articles selected for further study.

This section details all the content analysis of the 16 most relevant articles found in the literature. The content analysis was concentrated in reading the articles deeply to form the knowledge of the themes of acceleration programs, open innovation and research and development in the area, as described in details in Table 1. The table summarises the contribution of the 16 articles of the study showing the diversity of initiatives, interactions, models of work and outcomes from universities which search for R&D interactions with their partners regarding for Open Innovation and Acceleration Programs applied in two undergraduate programs at Pontifical Catholic University of Paraná (PUCPR) located in the south of Brazil.

**Table 1.** SLR content analysis.

Authors and year	Contributions	Limitations	Applications	AP	OI	R&D
Perkmann & Shildt (2015) [29]	Industrial participation in largescale scientific collaborations can guide scientific enquiry towards greater societal relevance.	Application in some fields of science. Pharmaceutical industry.	Blueprint possibilities for public-private research partnerships.	√	√	√
Smart et al. (2019) [30]	Application of Open Science as a pillar to Open Innovation and social improvement.	Open science implementation challenges.	Insights for more collaboration and policies between university-industry-government to foster science.		√	√
Guerrero & Urbano (2017) [31]	Effects of the links between enterprises with other organisations, or with universities and government for innovation performance.	Mexico context Innovation performance of Triple Helix.	Discussion about the entrepreneurial university model.	√	√	√
Arora et al. (2019) [6]	Division of innovation labour.	United States context.	Discussion about universities' activities in the innovation ecosystems.			√
Dezi et al. (2018) [7]	The shift in the role of universities from education to scientific knowledge and technology provider.	Italy context.	Discussion about the future of university role as a knowledge provider.			√
Van Belkum et al. (2019) [32]	Differences between academic and industrial R&D.	Diagnostic microbiology industry.	Possibility of replication of the comparison between other university-industry collaboration programs focused in R&D/R&I.			√
Lucia et al. (2012) [33]	Benefits of university-industry collaboration for all stakeholders, especially students.	Management challenges.	Improvements in curricula to match the professional reality Program management best practices.		√	
Breznitz and Zhang (2019) [34]	Identification of the main contributions of acceleration programs for students and startups.	University of Toronto context.	Replication of research instrument for other universities.	√		
Goduscheit & Knudsen (2015) [14]	The functioning and barriers for SMEs that are starting the collaboration with universities.	Startups results are not differentiated from the other SMEs.	Validation of hypotheses in Brazil context.		√	√
Howells et al. (2012) [8]	The success of informal and straightforward innovation programs.	Sample selection bias.	Redesign the role of universities and knowledge production.	√	√	√

Authors and year	Contributions	Limitations	Applications	AP	OI	R&D
Janeiro et al. (2013) [10]	The connections between service firms and universities.	Portugal context. Research subjectivity.	Further studies to identify industry-firm collaborations in Brazil.		✓	✓
Traitler et al. 2011 [11]	Innovation Partnerships and the Sharing-is-Winning model.	The study recommends culture change.	The development of business skills to foster open innovation for R&D.	✓	✓	✓
Natalicchio et al. (2018) [12]	The leverage knowledge from diverse areas and how universities converge it in new technologies for energy production patents.	Use of patents as the only innovation measure.	Opportunities for developing impactful technological solutions through knowledge recombination.		✓	✓
Howells and Cheng (2012) [35]	The role of Higher Education Institutions in Open Innovation Systems.	United Kingdom context.	Advances in the collaboration university-industry. Time-to-market orientation.	✓	✓	✓
Villasalero (2014) [36]	Technological capital accumulation in the Universities connected with Science Parks.	Spain context. Use of secondary databases.	Advances in selling technologies originated in Universities.	✓	✓	✓
Gálan-Muros & Plewa (2016) [37]	Analysis of barriers and drivers for University-business cooperation.	European context.	The focus on barrier reduction. Identification of barriers and drivers to Brazilian ecosystems.		✓	✓

The impacts of acceleration programs and open innovation initiatives in R&D found in the literature review are diverse. A variety of methodologies, university or industry approaches, makes it difficult to identify patterns of interactions in the ecosystem. Some characteristics of innovation is a non-linearity, and the combination of models of work, also found in SLR. In these 16 selected articles, there is the presence of different programs of acceleration which considered open innovation to foster R&D in the following approaches: industrial participation in largescale scientific collaborations [29]; effects of different links between enterprises with other organisations the role of the higher education institutions [35] and science parks in universities technological capital accumulation [36]. Two of these 6 articles show elements that match the acceleration programs. PIBIC Master match the literature that affirms that different links between actor may produce distinct innovation outcomes [31]. The PIBEP program matches the literature findings: the success of informal and focused AP [8]. Finally, both programs support and prove the change in the university role. The collaboration between university-industry has been generating great results over the years. However, to face the innovation and transdisciplinary context, the literature and the application cases prove the necessity of increasing the university actions between all entrepreneurial ecosystem actors to increase the impact of AP and OI in universities R&D.

## 2.2 Two Application Cases

This section presents two application cases that will analyse the impact of two acceleration programs at the Pontifical Catholic University of Paraná (PUCPR) in Brazil. The first program is called "Institutional Entrepreneurship and Research Scholarship Program – PIBEP" [38]. The innovative program was conceived in 2016 and focused on the preliminary stages of the creation of start-ups, such as start-up concept design. The main objective is to accelerate ideas of business to evolve to higher levels of maturity. The transdisciplinary teams are formed mainly by undergraduate, graduate or alumni students, to a comprehensive development of their start-ups [38].

The second program to be analysed called "Institutional Technological and Scientific Initiation Scholarship Program Combined Degree - PIBIC MASTER". This program aims to accelerate undergraduate students with excellent scientific performance, to conduct their undergraduate studies in parallel with a master's degree to obtain both degrees at the same time. The program also offers the possibility of six months of national or international mobility, where the student can develop his research in others

universities and organisations, experiencing external contacts through different networks of cooperation and immersion in other cultures [39] and [40].

In this context, the CIMO-logic, known for its contribution to the research organisation, has been adopted to facilitate the analysis of programs impacts (Table 2). The CIMO-logic encompasses four phases: Context (C), Type of intervention (I) Mechanisms (M), Results (O) [41]. The acceleration programs will be described by the CIMO-logic and evaluated for their interface according to the topics studied: open innovation and impact on research and development.

**Table 2.** CIMO logic applied to PIBEP and PIBIC MASTER – Combined Degree.

PIBEP CIMO logic		OI	R&D
Context	<ul style="list-style-type: none"> <li>• Flourishment of ideas and startups of students in different knowledge fields;</li> <li>• Demand for development of soft skills linked to the entrepreneurial profile;</li> <li>• Incubators and accelerators in Brazil require a minimal structured business to invest in startups;</li> </ul>	Required	Optional
Intervention	<ul style="list-style-type: none"> <li>• Teams formed by students from different areas (interdisciplinary groups) and different levels (undergraduate, graduate and alumni);</li> <li>• The program focus on the early stages of start-ups creation, like start-up concept design;</li> <li>• Three-month cycle program;</li> </ul>	Required	Optional
Mechanisms	<ul style="list-style-type: none"> <li>• Students develop one innovative idea to solve a customer/consumer need;</li> <li>• Students must present a minimum viable product (MVP) which means ideas transformed into business models, including prototypes;</li> <li>• Education and mentorship with specialized entrepreneurs;</li> </ul>	Required	Optional
Outcomes	<ul style="list-style-type: none"> <li>• Public presentation (Demoday) to investors;</li> <li>• Enterprises are running;</li> <li>• Patent registration;</li> <li>• Invitations for advanced acceleration programs outside the university;</li> </ul>	Required	Optional
PIBIC MASTER CIMO logic		OI	R&D
Context	<ul style="list-style-type: none"> <li>• Student acceleration in strict sensu post-graduation environment;</li> <li>• Acceleration of development of high-value research for society;</li> <li>• Qualified internationalisation of students and faculty and their researches;</li> <li>• High level for Scientific, technological and innovation aspects criterion;</li> <li>• Transdisciplinary education;</li> <li>• Development of scientific skills;</li> </ul>	Optional	Required
Intervention	<ul style="list-style-type: none"> <li>• 12 to 36 months program master's degree simultaneously to the undergraduate course with option up to 6 months of national or international mobility;</li> <li>• The program focus on scientific problem-solution;</li> <li>• Intense doctorate researcher supervision;</li> <li>• National and international collaboration;</li> <li>• High-quality research orientation;</li> <li>• Opportunity to Industry applied research;</li> </ul>	Required	Required
Mechanisms	<ul style="list-style-type: none"> <li>• Graduation program with a previous completed scientific program well succeed;</li> <li>• Attendance of all master's degree of the choosen area;</li> <li>• Students develop a scientific solution to a theoretical or real problem;</li> <li>• Intense reserch supervision;</li> <li>• Industry mentoring in case of university-industry collaboration;</li> <li>• Cultural immersion;</li> <li>• Peer review of research in different levels;</li> <li>• Research development and publication;</li> </ul>	Required	Required
Outcomes	<ul style="list-style-type: none"> <li>• Development of quality research with high value for society;</li> <li>• Accelerated formation of qualified human capital;</li> <li>• Employability;</li> <li>• Patents and publications;</li> </ul>	Optional	Required

The programs have a different approaches and results. PIBEP is a short-term program that emphasises the development of new businesses based on open innovation. The acceleration proposal is to transform ideas into business in initial stages in more advanced stages, with the idea validation, external investment, resulting in results: public business presentations to investors, the start of business operations, patent registrations and participation advanced acceleration programs. The transdisciplinarity of the students' academic backgrounds, their different levels of education and the previous experiences of the teams combined to the active participation of the other actors of the program in actions such as educational training, mentoring, and the experience of other companies highlights the impact of open innovation in the program.

Startups accelerated by the PIBEP program can be supported by scientific research. However, this is not a required element. Teams can choose research and development as

the basis of their startup and consequently obtain results that differentiate them from startups that have not decided by R&D approach. In addition to business development, the main objective of the program, publications and patents can result when teams choose to include research in development as part of their delivery. Participation in the PIBEP program enriches the student's experience while producing more complex innovation results, centred on the user, with greater market acceptance and, consequently, higher survival and success rates of the startups that passed through the program - demonstrating the direct impact of open innovation in the program.

The Combined Degree - PIBIC Master is an acceleration program that intensifies the academic experience in research, through the formation of human capital and the development of research with high quality and in a compressed time. The purpose of this acceleration program is to allow the student to complete his undergraduate studies simultaneously with the development of his master's research, combining the two degrees, and necessarily resulting in innovative and relevant research for society. Transdisciplinarity takes place between the different and complementary backgrounds of students and their research supervisors, through mobility between universities, in contact with companies. When the university-industry relationship is provided, new the areas of knowledge are required for the development of each research.

In the PIBIC MASTER - Combined degree program, several interactions take place between actors from the university and industry, with diverse contributions and directions for the development of research. Additionally, the option of mobility makes it possible to experience different cultures. All of these elements emphasise the open innovation character of the program in all its phases. Furthermore, considering the nature of the program, the impact of research and development to generate innovation is clear. The program does not have as obligatory a business development, and it must be considered that its scope emphasises research and development with the support of open innovation - however - the same student can participate in different entrepreneurship programs offered by PUCPR such as PIBEP.

Although the two acceleration programs have very different characteristics, both are directly impacted by open innovation and research and development that result in positive outcomes in the student's experience and their transdisciplinary professional education. The impact of acceleration programs is also positively distinguished by the actors who directly participate in the initiatives that also foster the development of the region.

### **3 Results and Discussion**

According with the literature review, the universities role, in constant evolution encourages the interactions of the university with other enterprises, including innovation partners on a broader innovation intermediary-type model [35]. Even that universities give attention to patent management [34], the emphasis on the knowledge trade by selling its research conflicts with development based on open innovation [36].

The transformation of knowledge with open science practices in parallel to OI used by universities increases their societal impact, [29] and [30] including in education [33] and [32]. Some factors seem to influence on innovation partnership with universities: effectiveness and speed; [11], connections, funding, organisational culture, internal characteristics, resource availability, relationships [37] and geographical proximity [7].

Innovation leaders, larger firms, Knowledge-Intensive Business Service (KIBS) sector are more likely to use universities intensively. The higher the innovation-intensity level, the greater the firm's reliance on universities. Moreover, larger firms tend to access universities more intensively [35] and [10]. This fact could be a barrier, especially to

SMEs, which have an excellent opportunity to work closely. However, it seems that universities should communicate better its benefits for innovation processes to enterprises of all sizes [35] and [14]. In this context, APs seem to be a great opportunity to Universities and SMEs to increase in collaboration. Firms that participate in acceleration programs have more robust performance in employment and product growth. [34]. Firms that spend time in APs, and whose director is a habitual entrepreneur, achieve a significant chance of experiencing growth, in particular, product growth, especially in emerging economies, where universities and research centres do cooperate with enterprises, producing a positive effect on their innovation performance. This effect is reinforced when the enterprise has a high-growth orientation [31], similar behaviour to start-ups, which could influence on University strategy and operation.

The acceleration programs PIBEP and PIBIC MASTER provided valuable insights about universities movement towards entrepreneurship practices. It promotes the value of universities acceleration programs for educational purposes but also to market-orientation demands, developing different skills which will able the students to perform more significant and competitive roles in their professional lives.

The application cases show some common points with the literature, showing that there is a change in the role of the university from a model of industry-academic to the complex model where the university is a facilitator and mentor for businesses. Additionally, it is possible to realize the crescent growing relation between university and industry have been impacting economic, environmental and socially of the innovation ecosystem where they are located.

## 4 Conclusion

This article has superficially discussed the evaluation of the impact of open innovation and acceleration programs on research and development performed by universities. It can be observed in the study is that few articles analyse university performance regarding OI and R&D and especially AP and universities' R&D. In this way, it was clear that the literature focus was on success rates of firms that cooperate with universities than assessing universities contributions themselves. Universities have been approaching with different open innovation models in order to cope with the current dynamic environment. The knowledge base provided by literature and application cases has been shown that universities are in transformation.

Moreover, given the nature of the innovation, these processes are in constant evolution, but they also can be accelerated. Another critical point to be considered is related to the more complex social and economic environment, universities, commonly known as qualified education providers, have been moving to knowledge suppliers. However, some key factors will determine the success of this new role. It mostly depends on the universities commitment to reduce the distance between the academic environment and the market. In this way, PIBEP and PIBIC MASTER present themselves as a clear solution of the universities moving to focus on innovation and entrepreneurial approach.

This literature review highlighted several lacks of information due to its broaden outcomes, that provided excellent opportunities for subsequent research. Consequently, further studies are necessary to explore OI and AP integration deeply in innovation processes considering universities are the centre of the ecosystem.

With different contexts, interventions, mechanisms and results, the acceleration programs that served as cases of application of these in this study showed the ability of universities to adapt themselves when they adopt a culture focused on innovation in its different approaches, indicating new possibilities for the creation of other flexible programs able to match industry and new business development based on research and



development. Although the research did not address the relationship with the industry itself, the authors believe that the universities transformations are going through in a knowledge-based economy and rise of the Fourth Industrial Revolution.

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