MARCO TÚLIO DINALI VIGLIONI

INNOVATION PERFORMANCE AND INSTITUTIONS:
EVIDENCE FROM LATIN AMERICA AND THE CARIBBEAN COUNTRIES

LAVRAS – MG
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Tese apresentada a Universidade Federal de Lavras, como parte das exigências do Programa de Pós-Graduação em Administração, área de concentração Estratégias de Negócios Globais e Finanças Corporativas, para obtenção do título de Doutor.

Prof.(a) Dra. Cristina Lelis Leal Calegario
Orientadora

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MARCO TÚLIO DINALI VIGLIONI

INNOVATION PERFORMANCE AND INSTITUTIONS: EVIDENCE FROM LATIN AMERICA AND THE CARIBBEAN COUNTRIES

DESEMPENHO EM INOVAÇÃO E INSTITUIÇÕES: EVIDÊNCIAS DE PAÍSES DA AMÉRICA LATINA E DO CARIBE

Tese apresentada a Universidade Federal de Lavras, como parte das exigências do Programa de Pós-Graduação em Administração, área de concentração Estratégias de Negócios Globais e Finanças Corporativas, para obtenção do título de Doutor.

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LAVRAS – MG
2021

To my Parents, who gave me infinite love and the adventure of studying;

and to all those who are seeking knowledge.

I Dedicate

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“It is not the past that matters, the wisdom is on the future”.

Pietro de Alleori Ubaldi

ABSTRACT

It is well known that knowledge activities, such as Research and Development (R&D) investments, is a firm' indistinguishable action to sustain cutting edge innovative activities, generate wealth and accelerate economic growth. Now more than ever, there is a growing awareness about fostering this valuable activity in developing economies. Nonetheless, and by their very nature, R&D is inherently risky. In particular, investing in R&D to increase innovation performance could be even more challenging for developing economies due to their institutional underdevelopment. Drawing from institutional economic theory, this thesis seeks to understand the effective condition of R&D investments and innovation performance in Latin America and Caribbean (LAC) countries and the effects of formal and informal institutions on the firms' and country's innovation performance. Inspired by a recent subject, this thesis adds significant contributions to the innovation and institutional literature. Considering a systematic literature review on state-of-the-art, Article 1 investigate and shed light about innovation and R&D across manufacturing industries in Latin America and the Caribbean countries. This systematic review enriches the innovation literature and adds new insights to further research. Moreover, the findings offer invaluable implications for policymakers and practitioners to foster innovative activities in Latin America. Article 2 considers a specific legal institutional mechanism – the Intellectual Property Rights (IPRs) protection. With the main objective to explore how the role of country intellectual property rights protection affects innovation performance, Article 2 adds to the literature a large methodological contribution and offers plenty of implications to policymakers concerning increasing the IPRs protection in developing economies. The findings revealed that both domestic and foreign innovation base activity positively increases innovation performance in a given country, albeit differences in domestic and foreign innovation patterns appear in the presence of strong IPRs protection. Article 3 explore how the firm's R&D performance is moderated by the relationship between R&D investments and the role of country institutions in Latin America investigates how the firm's R&D performance is moderated by the relationship between R&D investments and the role of country institutions in Latin America. This specific study enriches the literature with a new dataset of Latin American firms from Brazil, Chile, Mexico and Peru. Moreover, it is proposed a new methodological approach to increase the robustness of adopting several institutional indicators. The results support the argument that "institutions matter" for the long-term R&D investments. Overall, the results from this thesis revealed that LAC countries must urgently develop their institutions to stimulate long-term innovative activities. Regarding the IPRs, policymakers should develop an IPRs policy supporting a more "moderate" protection to stimulate the country's innovation performance by domestic and foreign innovation base activity. Ultimately, the findings suggest that policymakers should wake up their commitment to improving institutions. Therefore, this is fundamentally necessary for the managers to safely double down the sheer amount of R&D aiming the long-term.

Keywords: Innovation. Institutions. Research and Development.

RESUMO

É bem reconhecido que as atividades de conhecimento, tal como o investimento em Pesquisa e Desenvolvimento (P&D), é uma ação indistinguível da empresa para sustentar atividades inovadoras de ponta, gerar riqueza e acelerar o crescimento econômico. Agora, mais do que nunca, há uma consciência crescente sobre como promover essa valiosa atividade nas economias em desenvolvimento. No entanto, e por sua própria natureza, a P&D é inerentemente arriscada. Em particular, investir em P&D para aumentar o desempenho em inovação pode ser ainda mais desafiador para as economias em desenvolvimento, devido ao seu subdesenvolvimento institucional. Com base na teoria econômica institucional, esta tese busca compreender a condição efetiva dos investimentos em P&D e do desempenho em inovação nos países da América Latina e Caribe (ALC) e os efeitos das instituições formais e informais sobre o desempenho inovador das empresas e do país. Inspirada em um assunto recente, esta tese foi desenvolvida no formato de artigos, trazendo contribuições significativas para a literatura institucional e de inovação. Considerando uma revisão sistemática da literatura no estado da arte, o Artigo 1 investiga e auxilia a compreender melhor sobre a inovação e P&D nas indústrias manufatureiras de país da ALC. Esta revisão sistemática enriquece a literatura sobre inovação e adiciona novos *insights* para pesquisas futuras. Além disso, as descobertas oferecem implicações inestimáveis para os formuladores de políticas e profissionais fomentarem as atividades inovadoras na América Latina. O Artigo 2 considera um específico mecanismo institucional legal – a proteção dos Direitos de Propriedade Intelectual (DPIs). Com o objetivo principal de examinar como o papel da proteção dos direitos de propriedade intelectual do país afeta o desempenho da inovação, o Artigo 2 adiciona à literatura uma grande contribuição metodológica e oferece implicações para os formuladores de políticas no que diz respeito ao aumento da proteção dos DPIs nas economias em desenvolvimento. Os resultados revelaram que tanto a atividade de base de inovação doméstica quanto a estrangeira aumentam positivamente o desempenho em inovação em um determinado país, embora diferenças nos padrões de inovação doméstica e estrangeira apareçam na presença de forte proteção de DPIs. O Artigo 3 explora como o desempenho de P&D da empresa é moderado pela relação entre os investimentos em P&D e o papel das instituições dos países na América Latina. O Artigo 3 continua enriquecendo a literatura com um novo conjunto de dados de empresas latino-americanas do Brasil, Chile, México e Peru. Além disso, é proposta uma nova abordagem metodológica para aumentar a robustez ao adotar diversos indicadores institucionais. Os resultados apoiam o argumento de que "as instituições são importantes" para os investimentos de longo prazo em P&D. De modo geral, os resultados desta tese revelaram que os países da ALC devem desenvolver urgentemente suas instituições para estimular atividades inovadoras de longo prazo. Com relação aos DPIs, os formuladores de políticas devem desenvolver uma política de DPIs que apoie uma proteção mais "moderada" para estimular o desempenho inovador do país pela atividade de base de inovação doméstica e estrangeira. Em última análise, as descobertas sugerem que os formuladores de políticas devem despertar seu compromisso com a melhoria das instituições. Portanto, isso é fundamentalmente necessário para que os gestores dobrem com segurança a quantidade de P&D visando o longo prazo.

Palavras-chave: Inovação. Instituições. Pesquisa e Desenvolvimento.

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LIST OF ABBREVIATIONS

2SLS	Two Stage Least Squares
AIB	Academy of International Business
AIB-LAC	AIB – Latin America and the Caribbean
ALC	América Latina e Caribe
B3	Brasil, Bolsa e Balcão
BMV	Bolsa Mexicana de Valores
BRL	Brazilian Real
BVL	Bolsa de Valores de Lima
CC	Control of Corruption
CDM	Crépon, Duguet and Mairesse
CIS	Community Innovation Survey
CEPAL	Economic Commission for Latin America and the Caribbean
CMF	La Comisión para el Mercado Financiero
DPIs	Direitos de Propriedade Intelectual
e.g.	*Exempli gratia*
EMNEs	Emerging Market Multinational Enterprises
FDI	Foreign Direct Investment
FE	Fixed Effect
GAFs	Group-affiliated firms
GCR	Global Competitiveness Report
GDP	Gross Domestic Product
GE	Government Effectiveness
GII	Global Innovation Index
GLS	Generalized Least Squares
GMM	Generalized Method of Moment
GPI	Ginart-Park Index
H	Hydrogen
He	Helium
HSI	Homeland Security Investigations
IADB/IDB	Inter-American Development Bank
IBRD	International Bank for Reconstruction and Development

ICE	Customs Enforcement
ICT	Information and Communication Technology
IDA	International Development Association
i.e.	*Id est*
IFRS	International Financial Reporting Standards
INSEAD	*Institut Européen d'Administration des Affaires*
IPRPI	Intellectual Property Rights Index
IPRs	Intellectual Property Rights
ISI	ISI – Web of Science
ISIC	International Standard Industrial Classification of All Economic Activities
ISSN	International Standard Serial Number
IV	Instrumental variable
KIS	Knowledge Intensive Service
LAC	Latin America and the Caribbean
ln	Natural logarithm
MNEs	Multinational Enterprises
NICs	Asian New Industrializing Countries
NIEs	East Asian newly industrialized economies
NIS	National Innovation System
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
P&D	Pesquisa e Desenvolvimento
PCA	Principal Component Analysis
PLT	Patent Law Treaty
POLS	Pooled Ordinary Least Squares
PV	Political Stability and Absence of Violence / Terrorism
R&D	Research and Development
RICYT	RED DE INDICADORES DE CIENCIA Y TECNOLOGÍA
RL	Rule of Law
RQ	Regulatory Quality
S.A.B. de C. V	Sociedad Anónima Bursátil de Capital Variable
S&P	Standard & Poor's 500
S&T	Science and Technology

SAFs	Standalone firms
SAPI	Autonomous Intellectual Property Service
SCI	Science Citation Index
SHCP	Secretaría de Hacienda y Crédito Público
SJR	SCImago Journal & Country Rank
SLR	Systematic Literature Review
SMEs	Small-and-medium enterprises
SOEs	State-owned enterprises
TFP	Total Factor Productivity
TRIPS	Trade Related Aspects of Intellectual Property Rights
TSMC	Taiwan Semiconductor Manufacturing Company, Limited
U.S.	United States
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational Scientific and Cultural Organization
USD	U.S. Dollar
USTR	United States Trade Representative
VA	Voices and Accountability
VIF	Variance Inflation Factor
WDI	World Development Indicators
WEF	World Economic Forum
WGI	Worldwide Governance Indicators
WIPO	World Intellectual Property Organization
WTO	World Trade Organization
WWII	World War II

TABLE OF CONTENTS

PART ONE

Part One of this thesis begins with Section 1, Introduction, that briefly describes the research context and the whole endeavor of this PhD thesis. Section 2 provides the theoretical background adopted in each Article (1, 2 and 3) from Part Two of this Thesis. Section 3 details the methodology and data adopted in this thesis. Finally, Section 4 summary the conclusions of the whole thesis.

1 INTRODUCTION

In the 21st century, technology is here to stay. Now more than ever, modern economies are becoming further knowledge-based, and innovation becomes a sine-qua-non requirement (FLEURY; FLEURY; BORINI, 2013). Looking towards a modern and technological economy, developing innovation is essential to drive national competitiveness, long-term economic growth as well as society's living standards (KAFOUROS, 2008; CRESPI *et al*., 2014; VIGLIONI; BRITO; CALEGARIO, 2020). Accordingly, a meaningful part of a modern economic activity is channeled by Firms – a complex institution created by people to serve the purposes of people (PENROSE, 1959). For the sake of development, the innovative activities changed how modern civilization lives since the 18th century when wealth was concentrated in the hands of a few and poverty was widespread (WIPO, 2015).

To sufficiently achieve advanced progress, over the decades, a burgeoning stream of classic innovation literature has enriched our understanding that the primary engine that drives the economic growth heavily relies on an important knowledge activity – the firm R&D expenditures (AGHION; HOWITT, 1992; COE; HELPMAN, 1995; GRILICHES; 1979; MANSFIELD, 1984; MANSFIELD *et al*., 1971; ROMER, 1990). More recent research has demonstrated that firms from developed and developing economies that progressively invested in R&D increased their innovation outputs – e.g., new products, processes and sales revenue (ALAM; UDDIN; YAZDIFAR, 2019a, 2019b; ALAM *et al*., 2020; BIANCHINI; LlERENA; MARTINO, 2019; LEE, 2020). Indeed, R&D investments are crucial once allows economies to learn and effectively explore this knowledge and further develop their own ability to innovate (ALAM; UDDIN; YAZDIFAR, 2019a; CUERVO-CAZURRA; UN, 2010).

Incorporating a more encompassing perspective of innovation outputs, the United Nations Conference on Trade and Development – UNCTAD (2018), explain that the most widely used indicator of economic growth lies at the heart of R&D expenditure as a proportion of Gross Domestic Product (GDP). This innovation output is highly concentrated on innovation-driven economies. For example, in a virtuous cycle of innovation, Japan, South Korea, United States, United Kingdom, and other developed Western European countries are the global leaders in the 21st century, showing the remarkably R&D expenditure (CASANOVA; MIROUX, 2019; YANG; STOLTENBERG, 2014).

Conversely, in the case of developing economies – such as Latin America and the Caribbean countries – in 2014, the R&D expenditure as a proportion of GDP showed approximately the mark of 0.6 percent, value bellows the world average of 1.6 percent

(UNCTAD, 2018). Although the low levels of investment, a report developed by *Red de Indicadores de Ciencia y Tecnología* (RICYT, 2019) reveals that the growth and investment in R&D in the region surpassed 43 billion in 2008 and steadily increased to more than 63 billion in 2017. However, it continues far behind the top spots in terms of the R&D expenditure as a proportion of GDP – e.g., the Republic of Korea (4.27 %), Singapore (2.20 %), and China (2.02 %) (UNCTAD, 2018).

Notwithstanding that Latin America has shown some innovation active effort, or, at the very least, modestly grew in R&D expenditure, there are several intrinsic factors of R&D investments that may difficult Latin region in maintaining this activity (ROSSETTO *et al*., 2018; VIGLIONI; BRITO; CALEGARIO, 2020). First, R&D is still considered a recent phenomenon in Latin American countries (CRESPI *et al*., 2014; HALL; MAFFIOLI 2008), and firms hardly invest in disembodied technology – e.g., the R&D expenditure. For this and other reasons, the innovation activities in LAC countries reflect more incremental changes and adaption through imitation, reverse engineering, acquisition of machinery, equipment, and software (GOEDHUYS; VEUGELERS, 2012; FRANK *et al*., 2016; VIGLIONI; CALEGARIO, 2020).

Second, R&D investment may not automatically create value for the investing firms (ALAM *et al*., 2020). This is because R&D demands a long-term period to generate returns – e.g., it is an expensive and inherently risky activity once not all investments could be translated into innovations (ALAM; UDDIN; YAZDIFAR, 2019; HILLIER *et al*., 2011; KAFOUROS, 2008; UN; MONTORO-SÁNCHEZ, 2011). Third, it is related to the sunk costs' nature of R&D once they disappear over time (CUERVO-CAZURRA; UN, 2010; SUN; QU; LIAO, 2018). For this and other reasons, experts argued that public support, such as subsidies, is necessary for firms to achieve the best possible outcomes of investing in R&D (ANDRÉS; MIN, 2020; BIANCHINI; LlERENA; MARTINO, 2019; SASIDHARAN; LUKOSE; KOMERA, 2015).

By their very nature, obtaining returns from R&D indeed is an onerous process, and could be even more challenging for developing economies due to their institutional settings. Considering this specific perspective, the institutional conditions of developing economies are much more turbulent than in developed ones (HOSKISSON *et al*., 2000). Unfortunately, this is mainly because developing economies are usually characterized by highly institutional instability (MEYER; PENG, 2016; SINGH; GAUR, 2013; WU; WU; ZHUO, 2015). For instance, the institutional environments in developing economies become riskier due to the uncertainty of their economic and political systems (GAUR; KUMAR; SINGH, 2014; UDDIN *et al*., 2021). By implication, these economies fail to ensure efficient markets (MEYER, 2004),

which increases the transaction costs (WILLIAMSON, 2000; LIU; LI, 2019) and further limits the innovation performance.

On an ongoing basis, country institutions or the so-called "rules of the game" (NORTH, 1990; 1991) plays an important role in alleviating market failures for firms continuing investments, such as occur with R&D expenditures (GOEDHUYS; VEUGELERS 2012; HALL; MAFFIOLI 2008; VIGLIONI; BRITO; CALEGARIO, 2020). For instance, the bulk of the "rules of the game" includes policy initiatives and changes in legal frameworks (EGAN, 2017). In the case of R&D investments, this critical resource is not only a result of the firm (CRESPI; TACSIR; VARGAS, 2016; SUN; QU; LIAO, 2018), and more importantly, they are allocated by institutions or, at least, affected by them (CUERVO-CAZURRA; MUDAMBI; PEDERSEN, 2019; MEYER *et al*., 2009). Therefore, country institutions matter because ensure the returns from an uncertain investment, by managing their risk (EDQUIST; JOHNSON, 1997).

Accordingly, there is now a better understanding that "institutions matter" for innovation and economic growth. This is because institutions significantly shape and incentivize economic actors in a given society, influencing investments in physical, human and technological capital (ACEMOGLU; JOHNSON; ROBINSON, 2005; ACEMOGLU *et al*., 2019; KAUFMANN; KRAAY; MASTRUZZI; 2011; SUN; QU; LIAO, 2018). In this context, proper institutional settings for investment decisions in developing economies are important (PENG; WANG; JIANG, 2008) because well-developed institutions enable firms to conduct business more efficiently (GAUR; KUMAR; SINGH, 2014; SINGH; GAUR, 2013). Thereby, solid institutions, governments and industry organizations can make long-term commitments to finance technological activities (EDQUIST; JOHNSON 1997).

More recently, significant literature built on economic innovation and institutional theories tried to uncover a large number of factors that may have an impact on firm incomes and outcomes (ALAM; UDDIN; YAZDIFAR, 2019a, 2019b; ALAM *et al*., 2020; MEYER; PENG, 2016; WANG *et al*., 2015; WRIGHT *et al*., 2005). Nevertheless, few studies considered a complete model based on a formal and informal institutional framework (CANTWELL, DUNNING, LUNDAN, 2010; DUNNING; LUNDAN, 2008a), especially linking a set of institutions and the firm's R&D investments in LAC countries. Perhaps, this is because R&D in several developing countries is a relatively new phenomenon (EGAN, 2017).

Yet, in order to progressively increase innovation performance and the long-run sustainable growth, the strengthening and developing institutions across Latin American countries must be prioritized. Advancing, this thesis largely contributes to analyzing an

unexplored topic in a still relatively under-researched region. Therefore, this thesis addresses two very recent and specific subjects (investments in R&D and institutions) that raise meaningful questions and concerns in the developing economies studies.

1.1 Research question and objectives

As already foreshadowed, innovation performance, which inherently depends on R&D investments, has been seen as a vital activity in all countries that have experienced fast and dramatic economic development (OLAVARRIETA; VILLENA, 2014). In the long run, this distinctive characteristic of the firm is particularly relevant for developing economies. This argument continues attracting interest in several studies that consider developing economies and their uncertain institutional environment (ALAM; UDDIN; YAZDIFAR, 2019a; ALAM *et al*., 2020; BARASA *et al*., 2017; WU *et al*., 2016). A key limitation, however, is that most research examines countries from East Africa, the Middle East, North and Southeast Asia (ALAM; UDDIN; YAZDIFAR, 2019b; ANDRÉS; MIN, 2020; BARASA *et al*., 2017; WU, 2013; WU; WU; ZHUO, 2015).

Indeed, institutions vary by country (MEYER *et al*., 2009), and thus, as in any other region, Latin American shows considerably different institutional settings contributing to enrich the analysis. So far, little is known about innovation investments, such as R&D expenditures and the role of institutions in LAC countries. Ideally, and in order to advance and contribute to paving the road of innovation in Latin America, it is highly desirable to raise and answer the following main ***Research Question (RQ)***:

RQ 1: *What is the effective condition of R&D investments and innovation performance in Latin America and Caribbean countries and how formal and informal institutions affect the firm's and country's innovation performance?*

To answer the ***RQ 1***, it is fundamentally necessary to address one main research objective. In doing so, the objective serves as guidance to respond the main research question. Therefore, the ***Research Objective (RO)*** consists of:

RO 1*: Understand the effective condition of R&D investments and innovation performance in Latin America and Caribbean countries and the effects of formal and informal institutions on the firms' and country's innovation performance*.

To comprehend the main research objective, it is noteworthy to understand the shadows surrounding the R&D investments in LAC countries. This means that it is imperative to go deep and verify the role of institutions as well as their effects. In this regard, it is crucial to assess the innovation performance in the presence of a complex institutional scenario from LAC countries. Thereby, it is important to unfold the main research objective into three novel ***Specific Objectives (SO)***. Each ***SO*** is developed based on empirical articles (1, 2, and 3). The first consists of:

SO 1: *Investigate and shed light about innovation and R&D across manufacturing industries in Latin America and the Caribbean countries.*

To achieve the first specific objective, it is necessary to research the role of historical innovation context and R&D patterns in Latin American countries. Providing a systematic literature review, through Article 1, it is possible to comprehend the antecedents, motivations, issues and major innovation activities in LAC countries. After assessing systematic information, it is necessary to research a more specific and closely related institutional characteristic to R&D investments (HALL, 2005; HALL, GRILICHES; HAUSMAN, 1986; WANG, 2010).

Among the types of institutions, intellectual property right is a legal institution regulated by global international bodies, and more precisely, by the country's legal systems to protect firms' know-how and technologies (ALCÁCER; BEUKEL; CASSIMAN, 2017; MASKUS, 1998; 1997). Thereby, IPR protection is one of the critical institutional factors in the context of R&D investments that help firms to avoid knowledge misappropriation (LI; XIE, 2011). Therefore, assess the IPR's effects to foster R&D investments is an under-researched and ambiguous theme in Latin America. To address this issue, it is necessary to:

SO 2: *Examine how the role of country intellectual property rights protection affects innovation performance.*

This analysis is essential because if legal institutions are well-developed, such as IPR that supports innovative activities in one country, it is expected that countries increasingly develop their domestic innovation base activities. At the same time, it is equally suggestive that better IPRs in a given country attract more foreign innovative activities (KHOURY; CUERVO-CAZURRA; DAU, 2014; KHOURY; PENG, 2011; SMARZYNSKA-JAVORCIK, 2004).

Therefore, from an empirical research perspective, Article 2 combines both domestic and foreign assumptions in the presence of the country's IPRs protection to assess the country's innovation performance.

Finally, it is crucial to consider the firm-level analysis for a specific group of countries in Latin America (Brazil, Chile, Mexico, and Peru). The assessment of these countries allows to understand the effect of the country's formal and informal institutions on the firm's R&D investments. Therefore, it is appropriate to:

SO 3: *Explore how the firm's R&D performance is moderated by the relationship between R&D investments and the role of country institutions in Latin America.*

The third specific objective aims to investigate how the firm's R&D performance is affected by the country's institutions. More specifically, Article 3 examines whether and how the country's institutions interact with the firm's R&D investments. After assessing the firm's R&D performance, it is presented the robustness of results for the elasticity of several institutional indexes to check the overall effect and its relationships between a firm's R&D investments. Finally, this research presents a new subset index (hereafter sub-area index) to address the multicollinearity issues in the use of several institutional indicators.

1.2 Research justification

To tackle the main question and the set of objectives, the whole endeavor of this thesis consists of the argument that investing in R&D is crucial to improve the firm's innovation performance and the country's economic growth (CRESPI; ZUNIGA, 2012; KAFOUROS, 2008). This subject remains an essential feature of contemporaneous innovation studies (ROSSETTO *et al*., 2018; VIGLIONI; BRITO; CALEGARIO, 2020). Nevertheless, and according to a new study done by the Cornell University, INSEAD and the World Intellectual Property Organization (2019), the Global Innovation Index (GII) reveals that Latin America's innovation potential remains mostly untapped, which represents a critical issue to be exploited.

Considering these arguments, explore the LAC countries is necessary, once these economies face global pressures to foster sustained economic growth, reduce poverty, and improve the standards of living of its population (OLAVARRIETA; VILLENA, 2014). Furthermore, several transition economies beyond organization for economic co-operation and development (OECD) countries and developing economies across Asia (which is largely

represented by the East Asian newly industrialized economies – NIEs), started to invest massively in R&D activities, which resulted in a global technological upsurge (ALCORTA; PERES, 1998). In this sense, the global center for research and technology is shifting towards developing markets (CASANOVA; MIROUX, 2019; WIPO, 2019).

Potentially, Latin America has an industrial transformation underway, albeit, at the very least, the countries from this region present many challenges, which include the institutional settings (VIGLIONI; BRITO; CALEGARIO, 2020). Thereby, economists and policymakers are looking towards higher-level thinking to create new and better alternatives to lower poverty and foster economic growth through heavy R&D investments. To keep making progress, it is necessary to explore the complex institutional environment from Latin America once this will help to understand what affects the firm's R&D expenditures as well as the innovation performance in Latin America. All in all, this thesis will investigate several institutional issues related to the topic of innovation (e.g., R&D investments) considering a unique dataset for countries and firms from LAC countries. This is also one of the reasons why this thesis is a novelty.

More specifically, this thesis follows two main theoretical lenses, the economics of innovation literature based on R&D investments and the institutional theories. The justification for choosing these theories consists of the country's institutions constantly surrounding the firm's activities, and R&D investment is not an exception. Understanding the complementarities between these theories is necessary because – social or legal acts, as well as property, wealth, the concept of the State and its efficiency, the rights that regulate society's functioning – are not entirely isolated concepts but frequently interact with the firm's activities and their investment decisions (e.g., R&D expenditures). Therefore, it is highly expected that better institutions foster long-run economic growth and continuously affect the R&D investments and also the firm's innovative performance.

Finally, a deep investigation of the phenomenon of R&D investments and how the country institutions impact this kind of knowledge activity is of paramount importance for the managers and policymakers. This is because, historically, the institutions had the main objective of maintaining the State order and, at the same time, throughout rough domination and struggles, rise their empires seeking extraction of resources. The same story was dramatically repeated across LAC countries due to the Portuguese and Spanish settlement (NORTH, 1990). Fortunately, in modern and advanced societies, knowledge prevails. In this way, knowledge-related activities must be foster by well-developed institutions. Therefore, by developing the country's institutions increasingly aligned with the firm's R&D investments, policymakers can

better plan this knowledge activity for future generations, to advance and reach higher social welfare and reduce poverty at significant levels that would not possible or imaginable in the 21st century.

1.3 Theoretical contributions

This thesis adds novel theoretical contributions to innovation literature (ALAM; UDDIN; YAZDIFAR, 2019a; MANSFIELD, 1984; UN; MONTORO-SÁNCHEZ, 2011; ROMER, 1990; VIGLIONI; BRITO; CALEGARIO, 2020) and to the institutional literature in developing economies (ALAM *et al*., 2020; MEYER, 2001; NORTH, 1990; 1991; PENG; WANG; JIANG, 2008; WANG *et al*., 2015). One of the most significant theoretical contributions of this thesis comes from the criticism against the growth/innovation theory that purely assumes the static position of the firm internal resources (e.g., R&D expenditures) in explaining the investments in innovative activities. In contrast, heterogeneous aspects, not controlled by firms, are excluded. Put in other words, firm innovation activities are not completely endogenous but also exogenous, which means are susceptive to the country's institutional changes. To extend this argument, this, in turn, requires a broader and richer perspective, considering, for example, the country's institutional condition that may positively or negatively affect the R&D expenditures and, thereby, the innovation performance.

Another novelty from this thesis consists of the adopted methodology, which encompasses a range of approaches (e.g., philosophical and scientific approaches, statistical procedures and robust econometric estimators). Thus, we extended prior innovation literature in emerging economies providing mixed research approaches to understand and explain the innovative performance and the R&D investments at the country- and firm-level. Based on several developing economies from Latin America, this thesis adds new insights to the existing theoretical and empirical studies in LAC countries.

Part Two of the thesis (see topic 1.5 Structure of the Thesis) consists of a collection of three empirical Articles (1, 2 and 3). Article 1 begins with a deep Systematic Literature Review (SLR). All in all, the analysis provided by Article 1 adds support to the quantitative analysis from Articles (2 and 3). Considering this, each empirical Article (1, 2, and 3) has significant contributions that deserve to be detailed in the following paragraphs.

Article 1 contributes with an in-depth literature analysis across Latin America, which investigates the innovation patterns and R&D activities across firms and countries. The study is unique because it develops a scientific and philosophical approach to propose and explain

how innovation materializes and how essential it is for economic growth. Moreover, this study methodologically contributes with previous practice (e.g., CALABRÒ *et al*., 2018; CEIPEK *et al*., 2019; DANESE; MANFÈ; ROMANO, 2018; VRONTIS; CHRISTOFI, 2021), with a systematic literature review adopting several scientific knowledge sources, such as the ISI – Web of Science, Scopus database (Elsevier B.V.), and Taylor and Francis Group. Specifically, such an approach allows us to research a rich number of empirical cases, going forward the previous literature in Latin America (e.g., BRENES *et al*., 2016; OLAVARRIETA; VILLENA; 2014; ROSSETTO *et al*., 2018). In order to contribute to the innovation literature in Latin America, we propose a new approach combined with the systematic literature review to organize extant knowledge – hereafter "state-of-the-art".

Article 2 contributes to adopting macroeconomic data from several databanks, such as the RICYT, Worldwide Economic Forum (WEF), and the World Bank. These large international bodies provide relevant sources of information to assess the innovation output throughout 15 LAC countries. Focusing on this region, the research draws on one specific legal institutional setting – intellectual property rights protection. We put into the empirical analysis the LAC countries because some aspects of legal institutions and innovation activities (e.g., IPRs and R&D investments) vary by country' development and geographic regions (LALL, 2003; LEE; ALBA; PARK, 2018; MASKUS, 1998; NEVES *et al*., 2021; STEL *et al*., 2019).

Looking beyond, we continue to research a region in which countries are increasing the investments toward innovation activities through R&D expenditures and at the same time show a mix of weak and strong IPRs regimes (e.g., KHOURY; PENG, 2011; LEE; ALBA; PARK, 2018; PÉREZ *et al*., 2018; VIGLIONI; BRITO; CALEGARIO, 2020). Using several components from the Institutional Pilar from the WEF reports, this research contributes by offering a unique IPRs protection index to understand how the strengthening of IPRs interacts with the domestic and foreign innovation activity in a given country.

Furthermore, this study also contributes to institutional literature once it adopts both formal and informal structures into the analysis (NORTH, 1990; 1991). Theoretically, we look forward to building on earlier scholarship (e.g., PAPAGEORDIADIS; CROSS; ALEXIOU, 2013; PAPAGEORDIADIS; McDONALD, 2019; SMARZYNSKA-JAVORCIK, 2004) positing two specifics IPRs institutions as proxies to control the intellectual property within a country. First, as a formal institution, we chose the levels of *de jure* legal protection "Law on the books" (TRIPS agreement). Second, as an informal institution, we chose the quality of *de facto* enforcement "Law in practice" (USTR's Special 301).

Article 3 specifically contributes to the existing literature on R&D and institutions, bringing new firm-level data. Thereby, this research provides a first-hand analysis adopting a unique dataset to measure the firm's R&D investments considering four Latin American countries – Brazil, Chile, México and Peru. The study is unique because it concentrates on a group of countries from Latin America with large R&D expenditures (see UNESCO, 2021) and with considerable effort to innovate (CRESPI *et al*., 2014; FLEURY; FLEURY; BORINI, 2013; PÉREZ *et al*., 2019).

Specifically, researchers traditionally consider that innovation at the firm-level has been all about the specific characteristics of the firm (ANDRÉS; MIN, 2020), missing the external factors that affect the R&D expenditures. In addition, research analyzing the institutions and investments in innovative activities is undeniably scarce (BIANCHINI; LlERENA; MARTINO, 2019), especially in developing economies (ALAM; UDDIN; YAZDIFAR, 2019b; BARASA *et al*., 2017). Despite the past contributions, there is still a large gap between these two concepts in developing economies (ALAM; UDDIN; YAZDIFAR, 2019a; SUN; QU; LIAO, 2018), especially in Latin America, in which studies of innovation initiated late (PÉREZ *et al*., 2019). Thereby, questions such as how formal and informal institutions affect firm investments (e.g., R&D expenditures) have been relatively unexplored regarding Latin American countries. Therefore, this study continues contributing to a recent debate in developing economies considering the firm's R&D investments in the presence of several institutions (e.g., ALAM; UDDIN; YAZDIFAR, 2019a; BARASA *et al*., 2017; SASIDHARAN; LUKOSE; KOMERA, 2015).

Ultimately, following (ALAM; UDDIN; YAZDIFAR, 2019a; HILLIER *et al*., 2011; SASIDHARAN; LUKOSE; KOMERA, 2015), this research adopts the Generalized Method of Moments (GMM) estimator and instrumental variables (IV) to address endogeneity issues. While this research complements the past literature using a robust estimator, it largely contributes to developing a new approach to an issue apparently unsolved. Looking forward, the research significantly contributes by developing three institutional sub-area components extracted from Kaufmann, Kraay and Mastruzzi (2011). While this novel approach allows addressing multicollinearity (to increase the robustness of results), it further contributes to offering a new and reliable measure to evaluate the effect of institutions in further research.

1.4 Practical implications

There are practical contributions for firms to keep investing in R&D activities as well as policymakers to support this type of investment. Specifically, this thesis offers essential practical contributions for Latin American countries and other developing economies that face similar institutional issues and, at the same time, show difficulty in fostering innovation performance in their countries. Accordingly, it is necessary to show to policymakers the importance of country's institutions and their effects on the firm's R&D activities. This is fundamental to achieve the best innovation outcome for their countries.

Moreover, the results provide essential informs to managers and policymakers regarding a specific legal institution. For example, one essential contribution for policymakers and corporate managers is that the legal institutions, such as the country's IPRs protection, affects the domestic and foreign innovation activity in a given country. Although the relationship seems rather simplistic, results are not always obvious, generating distinctive information for policymakers and corporate managers. For this and other reasons, it is necessary to understand the effects of IPRs on domestic and foreign activity to balance this specific institution and, thereby, benefit both innovator sides.

More specifically, the findings from this thesis can help managers understand how the role of formal and informal institutions can affect R&D investments. This is crucial once managers can work together with policymakers or, at the very least, pressure them for a more efficient institutional environment looking towards a sufficiently long-term R&D performance. Therefore, the thesis offers a solid ground for policymakers and managers, together, pave the road to long-term innovation in Latin America.

1.5 Structure of the Thesis

The structure of the thesis is systematically built out of two parts, as indicated by Figure 1. Specifically, Part One concerns the introduction, theoretical background, methodological procedure and the summary of conclusions. In other words, Part One explicitly discusses the primary endeavor of this thesis, as well as the main question, objectives, theory and methodological procedure adopted in each empirical Article. Ultimately, the summary of conclusions recapitulates the whole endeavor of this thesis and shows general discussion and conclusions by summarizing the main findings of each Article (1, 2, and 3). Part Two is built

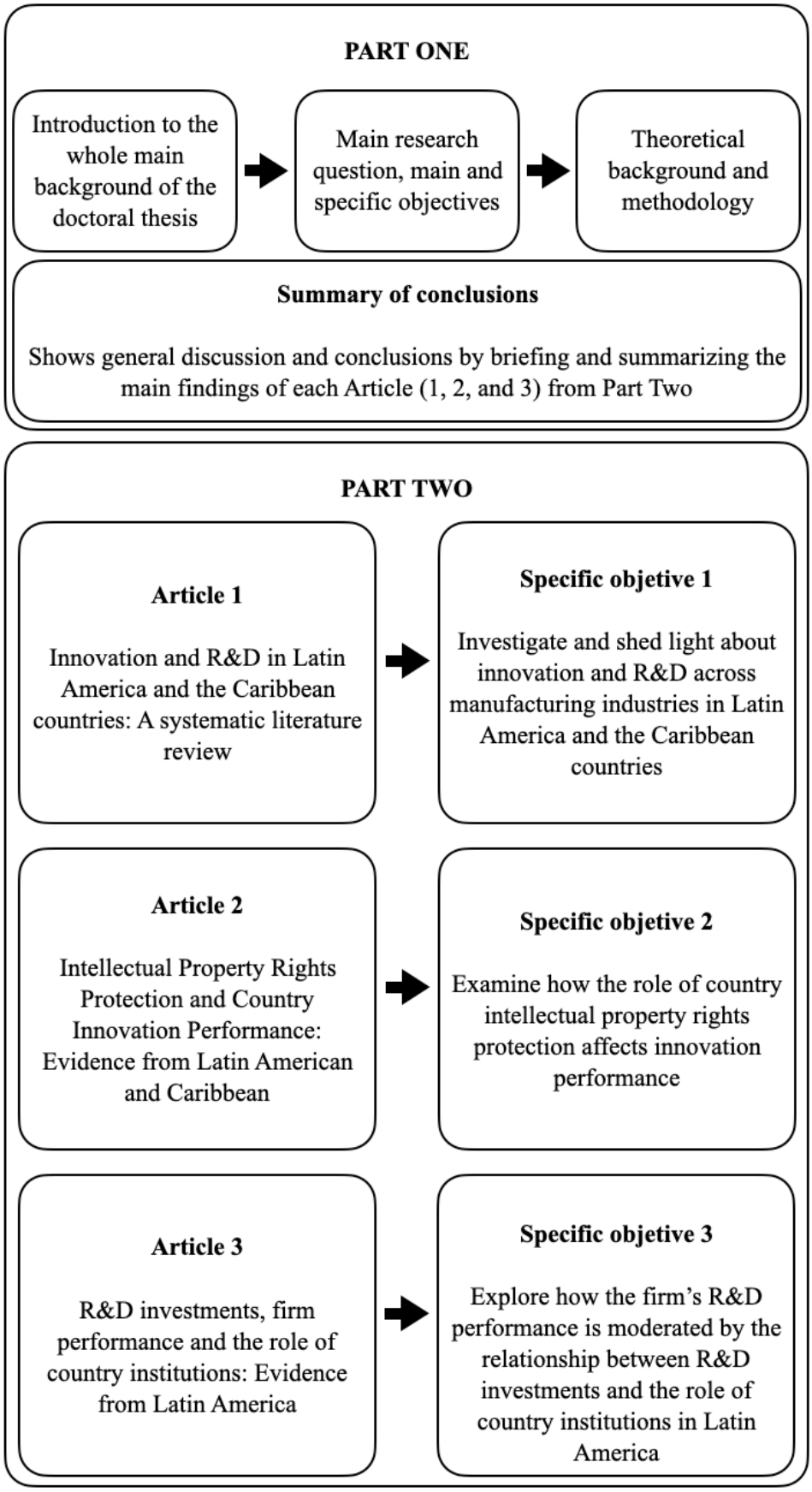
on traditional empirical studies, Article (1, 2, and 3). Therefore, Figure 1 and the following paragraphs briefly map the structure of this thesis.

Article 1 – *Innovation and R&D in Latin America and the Caribbean countries: A systematic literature review*. This study presents a philosophical and scientific approach to explain how innovation and R&D are important. Moreover, this research overviews the technological scenario in Latin America, and it addresses essential questions of R&D and innovation topics, providing an in-depth analysis of the Latin American innovation and R&D scenario.

Article 2 – *Intellectual Property Rights Protection and Country Innovation Performance: Evidence from Latin America and Caribbean*. This study approaches both aspects of domestic and foreign innovation base activities considering a specific institutional aspect, the Intellectual Property Rights Protection within a country. Building on the country's domestic and foreign innovation base activities and the IPR protection, it is possible to assess the country's innovation performance.

Article 3 – *R&D investments, firm performance and the role of country institutions: Evidence from Latin America*. This study assesses the firm's R&D performance in the presence of several country institutional factors. Despite several tentative to understand what determines the firm's R&D investments, this research shows how the role of the country's institutions interacts with the firm's R&D expenditures.

Figure 1 – Structure of the PhD thesis.



Source: The Author.

2 THEORETICAL BACKGROUND

To achieve the main research objective, the thesis draws on two major theories – the economic theory of innovation (SCHUMPETER, 1934; 1942) and the institutional theories (NORTH, 1990; 1993; SCOOT, 1995). While the former mainly analyses the technological factors of the firm (e.g., R&D investments) that foster and develop an economy (GRILICHES, 1998; ROMER, 1990), the latter holds that organizations are governed by an institutional environment constituted by formal and informal governance structures, that may affect the firm's decisions in a given society (DUNNING; LUNDAN, 2008a; KAUFMANN; KRAAY; MASTRUZZIET, 2011; KHANNA; PALEPU, 2010; NORTH, 1991). Therefore, and to clarify these theories the following sessions show the main concepts and ideas adopted by each Article (1, 2, and 3) in Part Two of this Thesis.

2.1 The economic theory of innovation

After the milestone works of Joseph Schumpeter (1934; 1942), innovation becomes the cornerstone to foster technological change[1] and economic development in all societies. The subsequent seminal researches of Robert Solow (1957; 1956) have sought to recognize how important is to rely on knowledge expenditures to improve the firms' growth. Going forward, the classic work of Edith Penrose (1959) "The Theory of the Growth of the Firm" brought to the international business, strategic management and economics, solid ground to understand the firm's growth motivations.

Since then, and contributing to the whole of innovation (e.g., AGHION; HOWITT, 1992; GRIFFITH; REDDING; REENEN, 2004; GRILICHES, 1986; 1989; GROSSMAN; HELPMAN 1991; MAIRESSE; MOHNEN, 2010; MANSFIELD, 1984; ROMER, 1990) researchers significantly contributed arguing that intensive knowledge activities are an essential factor in fostering the economic development. Overall, past innovation studies based on the endogenous theory – the so-called Neo Schumpeterian growth theory- assume that the firm's internal or endogenous factors (e.g., capital, physical resources, skilled human resources) are the main contributions to innovation and growth in a country.

[1] Technological change is the rate at which new knowledge is diffused and put into use in the economy (AUDRETSCH *et al*., 2002, p. 155).

More later, only after the works of North (1990; 1991) considering the institutional forces, the modern growth theorists, such as Grossman and Helpman (1990), Romer (1990) and Aghion and Howitt (1992) started to accept the idea that accumulation of capital and also the R&D expenditures are just "causes" of growth (ACEMOGLU; JOHNSON; ROBINSON, 2005). Accordingly, Acemoglu, Johnson and Robinson (2008) explain why some countries are much richer than others and why they grow much faster than others because it is needed to look for potential fundamental causes, such as the differences across countries. Consequently, in modern times, theorists "are able to focus more clearly on the role technology, business enterprise, and supporting institutions play in economic growth and development" (TEECE, 2009, p. 187).

2.2 From the basic research to Research and Development

In modern times, Science and Technology have long been regarded as important determinants of economic growth and technological change (AUDRETSCH *et al*., 2002). In this context, an important characteristic of corporations consists of firms are not only influenced by technological change but by their investments in resources in an effort to influence the rate and direction of that change (MANSFIELD *et al*., 1971). Thereby, there is a significant distinction in the process of formation of the term R&D. Considering this, the authors explain that the firm's knowledge activity is divided into three major phases.

The first phase is basic research, a process devoted entirely to the creation of new knowledge. At this stage, the OECD (2002, p. 31) defines basic research as "*experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view*". For example, Link (1982) explains that basic research includes several areas, both related to the physical and biological sciences.

At this stage, firms carry out some basic research, but as would be expected, it accounts for a relatively small proportion of their R&D work (MANSFIELD *et al*., 1971). For instance, the OECD (2002, p. 82) posit that "in theory, basic research, at least non-oriented basic research, cannot be assigned to product fields". Therefore, the basic research is used as an informational input into other inventive activities (ARROW, 1962).

The second phase is applied research, which is expected to have a specific practical payoff. At this stage, the applied research is an investigation process in order to acquire new knowledge (OECD, 2002). The main distinction between basic and applied research is that the

applied research is based on the aim of the work, while the basic research is being carried out to obtain new knowledge for its own sake (MANSFIELD *et al*., 1971). All in all, applied research aims to generate knowledge that can be used for specific products and processes. For example, when the scientist investigates the conductivity of different materials to create a faster computer processor (KAFOUROS, 2008).

Finally, the third phase is represented by the development[2], with the attempt to reduce the research[3] findings to practical application. At this stage, "major development projects try to bring entirely new types of products and processes" (MANSFIELD *et al*., 1971, p. 3). Essentially, the OECD (2002) defines research and development as:

> Research and development by a market producer is an activity undertaken for the purpose of discovering or developing new products, including improved versions or qualities of existing products, or discovering or developing new or more efficient processes of production. (OECD, 2002, p. 176).

Along these lines, the modern economic theory of innovation acknowledges that R&D investment is the critical element to hold long-term economic growth (AGHION; HOWITT, 1992; ROMER, 1986; 1990). More than anything else, R&D activities represent a particular form of value-added activity (DUNNING; LUNDAN, 2008b). This is because R&D enables firms to innovate and develop new technologies (LEE, 2020).

In addition, Audretsch *et al*. (2002) explain that R&D intensive firms have two primary purposes to conducts R&D. The first provides the resource base from which the firm can respond to the market opportunity, in other words, competitive advantage. Second, scientists involved in R&D activities are part of the internal resource that facilitates the firm's ability to make decisions regarding the technical merits of others' innovations. In this perspective, Figure 3 illustrates the role of R&D and the firm performance by different channels leading to the generation of new technologies, products, services and processes that may reduce costs, generate more revenue and enhance firm competitiveness (KAFOUROS, 2008).

Aside from the direct impacts on firm performance (e.g., better products and process innovations), potential indirect impacts (e.g., learning, increasing learn by absorptive capacity) come from investing in R&D. For example, Cohen and Levinthal (1989; 1990) essentially

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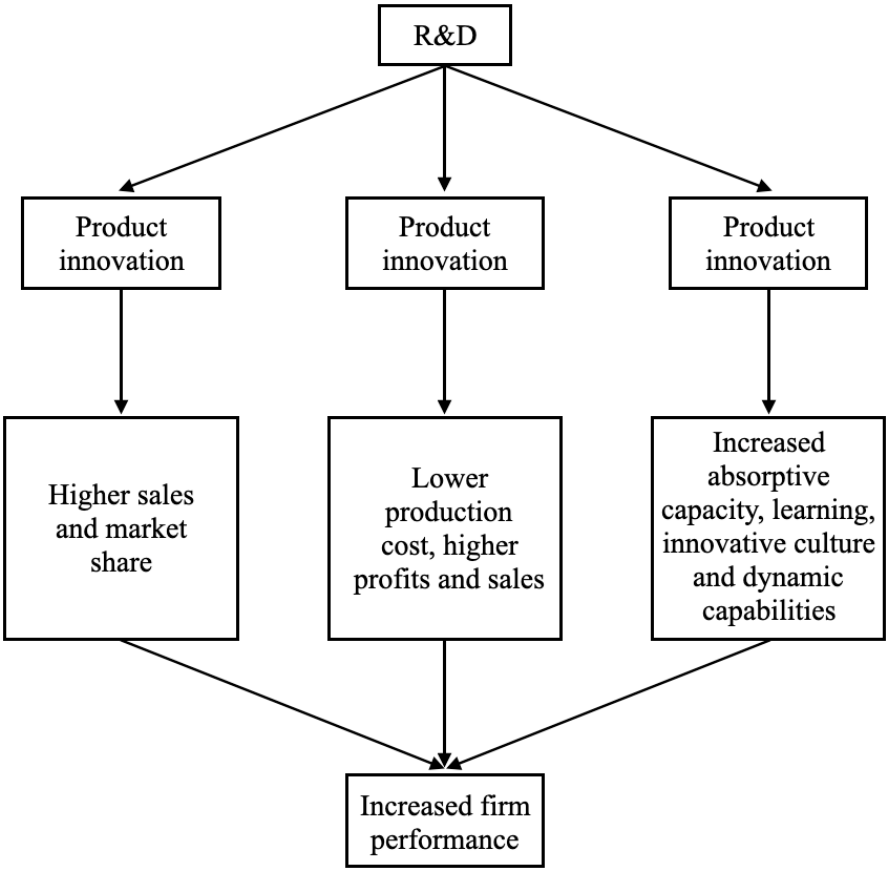
[2] Research is oriented toward the pursuit of new knowledge, whereas development is oriented toward the capacity to produce a particular product (MANSFIELD *et al*., 1971, p. 3).
[3] Research generally entails more uncertainty of outcome and requires more time for completion than development (MANSFIELD *et al*., 1971).

discussed the importance of investing in R&D. This is because the firm performance can be indirectly affected by enhancing a firm's absorptive capacity, which allows firms to identify, recognize and assimilate the external knowledge (COHEN; LEVINTHAL, 1990). For these reasons, internal R&D activities seem the major success element in product and process innovation (ALAM; UDDIN; YAZDIFAR, 2019a; 2019b; CRESPI, ZUNIGA, 2012). Contributing to the whole, the indirect effects of R&D activities are fundamental to learn, imitate, adapt foreign technology and, thereby, develop new competencies (CASTELLACCI; NATERA, 2016).

Figure 2 – R&D and the firm performance.



Source: Extracted from Kafouros (2008, p. 26).

Nonetheless, albeit R&D is considered a strong advantage, it is time-consuming, expensive and radically surrounded by high levels of uncertainty and information asymmetry (HILLIER *et al*., 2011; KAFOUROS, 2008). In other words, even with large R&D budgets, R&D investment and success at innovation is not automatically create value for the firms (ALAM *et al*., 2020). By this means, R&D projects take time to be completed and cannot

always have an immediate impact on the firm performance. To clarify, an industrial example clearly illustrates key aspects of R&D activities.

M&M's is a famous brand from Mars Incorporated, a U.S company that sells peanuts coated with chocolate and a colorful candy shell. Forrest Edward Mars, son of Franklin Clarence Mars, invented this famous chocolate in partnership with William F. R. Murrie – Mars & Murrie, filling a product patent by 1941. Unfortunately, before the first chocolate with candy shell is displayed on the long lines market's shelves, Mars company was obligated to exclusively supply to Unites States Military Army, which officially entered World War II (WWII) in December 1941. The inventors were strongly surprised and the situation involved immense risks, once the competition is constantly pushing around the company. To get rid of this, and assuming the risks, the Mars company mainly started to supply the U.S army with the M&M's chocolate. After WWII was over, and pushing for sales with the ending of war rationing, the candies were extremely popular with American veterans, that free promoted the brand and the M&M chocolate in their families.

Synthesizing this passage, it clearly demonstrated that how R&D activities are essential to developing a new innovative product. In this case, to reach high innovation output a previous knowledge stock is highly desirable (ROMER, 1990). Moreover, the example clearly shows how investing in R&D is challenging, expensive, riskier – e.g., required a rapid adaptation to supply the demand in WWII, and also the possibility of knowledge leakage during this period. Furthermore, it is a time-consuming activity, or, at the very least, needs a long-term return. Considering this historical example, in modern society, there is no technological firm that is exempt from all these processes and externalities.

All in all, the same can be replicated to a slew of types of inventions, especially when demands high R&D investments. Furthermore, the example can be extended to heterogeneous industry sectors, such as the chemical industry, other food products and also beverages, pharmaceuticals, electronics, semiconductors, automobiles, aerospace, and other industries. Therefore, this is because firms usually take years of research to get a proper return from their R&D investments.

2.3 The role of country's institutions

As a social phenomenon, institutions play a crucial in legitimizing the firm's activities (DiMAGGIO; POWELL, 1983; 1994; SCOTT, 1995; ZUCKER, 1987). For this and other reasons, the phenomenon of institutions was furtherer extended to economics activities

(NORTH, 1990; 1993; WILLIAMSON, 2000). More specifically, institutions in a given country are fairly known as "the rules of the game" (NORTH, 1990), which certainly encompasses plenty of potential influences on firms' activities.

Ideally, institutions have an essential role in supporting the proper functioning of society and control the behavior of individuals and firms (CUERVO-CAZURRA; MUDAMBI; PEDERSEN, 2019; KRAMMER, 2015). For example, one of the most meaningful characteristics of institutions consists of providing the basic structure by which human beings throughout history have created order and attempted to reduce uncertainty in exchange, providing a structure to everyday life (NORTH, 1990). Therefore, the role of institutions in a modern economy reduces both transaction and information costs (COASE; 1937; HOSKISSON *et al*., 2000; WILLIAMSON, 2000).

2.4 Formal and informal institutions

Contributing to the whole, the level of institutional development of a country is associated, for example, with the configuration of its formal and informal institutions (DUNNING; LUNDAN, 2008a; FLEURY; FLEURY; BORINI, 2013). These formal and informal institutions govern individuals and the firm behavior (PENG; WANG; JIANG, 2008). Specifically, Peng (2014) points out that the "formal and informal institutions are supported by three pillars" as identified by Richard Scott, (1) regulatory, (2) normative, and (3) cognitive pillars.

a) Formal institutions: are composed e.g., by Laws, with the (1) regulatory pillar, rules, with coercive power of governments.
b) Informal institutions: are indicated e.g., by norms, cultures, ethics, with (2) normative and cognitive power. The normative pillar refers to the values, beliefs, and actions, and the (3) cognitive power refers to the internalized, taken-for-granted values and beliefs that guide behavior.

Accordingly, institutions bear a set of formal rules and informal standards devised to guide interactions in society (FLEURY; FLEURY; BORINI, 2013). The difference between both types is clear. While formal institutions correspond to the regulative pillar (SCOTT, 1995), informal institutions include "traditions, customs, moral values, and all other norms of

behavior" that have passed the test of time (NORTH 1990). More specifically, institutions show several different classifications, which deserve to be clarified in the next topic.

2.5 Institutions – Classifications

Taking in other perspectives, the literature points out that institutions have several classifications or signatures. Cuervo-Cazurra, Mudambi and Perdersen (2019) explain that the institutions can be classified by their quality. For instance, Barasa *et al*. (2017) point out that institutional quality is related to the situations where the country or region has low corruption, a strong rule of law and a high degree of regulatory quality. That is, institutional quality may influence the structure of social and economic development (NORTH, 1990).

In the context of innovations, the country's institutional quality refers to the development of institutions that support innovation in its market (WU; WU; ZHUO, 2015). Specifically, Yasar, Paul and Ward (2011) explain that the high-quality institutions will reduce two types of firms' production costs: the transformation costs, and transaction costs, while poor quality institutions instead make contract enforcement difficult or make the payment of bribes necessary (i.e., corruption). In other words, quality refers to institutions that have better or worse characteristics (CUERVO-CAZURRA; MUDAMBI; PERDERSEN, 2019).

Another important classification relies on institutional strength. The key aspect of institutional strength refers to the level of control over the behavior of individuals and companies (CUERVO-CAZURRA; MUDAMBI; PERDERSEN, 2019). Strong institutions ensure adequate access to finance the firm activities, high-quality human resources as well as a low tax burden (QU; QU; WU, 2017). In addition, strong institutions ensure the return from an uncertain investment by managing their risk (EDQUIST; JOHNSON, 1997).

Apart from these, strong institutions reduce the uncertainty by creating structures favorable to the execution of established contracts, thereby reducing transaction costs (FLEURY; FLEURY; BORINI, 2013). This is the case, for example, of Intellectual Property Rights in a given country. This is because when the IPRs is strong, it may facilitate domestic innovation (COE; HELPMAN; HOFFMAISTER, 2009; PARK, 2008; WILLOUGHBY, 2018) and encourage foreign innovators to generate innovations in a given country (ALCÁCER; BEUKEL; CASSIMAN, 2017; ALLRED; PARK, 2007; KIM *et al*., 2012; SWEET; MAGGIO, 2015). For these and other reasons, it is highly likely that stronger institutional settings help to foster R&D investment and improve knowledge in a country (ALAM; UDDIN; YAZDIFAR, 2019a). On the other side, weak institutions fail to ensure effective markets or, at the very least,

undermine markets and firms' activities (KRAMMER, 2015). For instance, firms operating in an economy with weak legislative institutions will encounter high transaction costs and high uncertainty (WU, 2013).

Finally, a peculiar and rare institutional classification relies on institutional voids. Rottig (2016) explains that one of the key characteristics of many developing economies includes the institutional voids, or, the underdevelopment or lack of certain institutions. For instance, in developing economies (KHANNA; PALEPU, 1997), the lack of institutions is likely to harm the market transaction and the consumer welfare (KHANNA; PALEPU, 2010; YOUNG *et al*., 2014). Nonetheless, it is important to mention that countries rarely lack institutions, i.e., voids (CUERVO-CAZURRA, GAUR, SINGH, 2019). This is because, voids refer to countries either having institutions or not, which in other words, is a rare case (CUERVO-CAZURRA, MUDAMBI, PEDERSEN, 2019).

2.6 Country's governance structures

There are several alternatives to measure the country's institutions. One of them is the governance structures in a given country, defined as "the traditions and institutions by which authority in a country is exercised" (KAUFMANN; KRAAY; MASTRUZZI, 2011, p. 222). Moreover, the authors explain that the Worldwide Governance Indicators (WGI) is a long-standing research project to develop cross-country indicators of governance. The WGI (2021) body has covered over two hundred countries "since 1996, for six broad dimensions of governance. Table 1 describes the six dimensions of traditions and institutions by which authority in a country is exercised.

Kaufmann, Kraay and Mastruzzi (2011) synthesis the six dimensions into three areas. The first is composed of (a) *the process by which governments are selected, monitored, and replaced*. Herein, it predominates the dimensions of voice and accountability and political stability and absence of violence/terrorism. The second consists of (b) *the capacity of the government to effectively formulate and implement sound policies*, composed of government effectiveness and regulatory quality.

Table 1 – Country's governance structures.

#	Institutional dimension	Description
1	Voice and Accountability (VA)	Capturing perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.
2	Political Stability and Absence of Violence / Terrorism (PV)	Capturing perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism.
3	Government Effectiveness (GE)	Capturing perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.
4	Regulatory Quality (RQ)	Capturing perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.
5	Rule of Law (RL)	Capturing perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.
6	Control of Corruption (CC)	Capturing perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

Source: Adapted from Kaufmann, Kraay and Mastruzzi (2011, p. 223).

Finally, the third is represented by (c) *the respect of citizens and the state for the institutions that govern economic and social interactions among them*, structure by the rule of law and control of corruption. Considering the role of institutions in a given country, it is necessary to review the literature to understand more about the effects of institutions at the country- and firm-level. This allows capturing the effects of institutions on firm R&D investments, and therefore, the innovation performance.

2.7 The role of country' institutions and the innovation performance

Regarding the impact of the institutions on firm activities, the rules of the game are clearly responsible to affect the firm economic performance. This is because institutions are much more than merely background conditions (LU; TSANG; PENG, 2008; PENG; WANG; JIANG, 2008). For this and other reasons, Liu and Li (2019) explain that the foundation in institutional economics (an institution-based view of a firm), accounts for the impact of institutions on firm strategy and organizational and economic outcomes.

For example, in the case of voice and accountability, it is simply an indicator of strong democracies (BOUDREAUX, 2017). Notably, more democratic institutions help to control the

use of power by the government, ensuring that government policies, including innovation, are well aligned with the private investments – e.g., R&D (WU *et al*., 2016). Moreover, democratic countries show relevant and positive results for innovation activities. For example, Acemoglu *et al*. (2019) documented that the democratization process in a given country increases the GDP in the long run. That is, in countries with high GDP, firms generally access more R&D activities (ALAM; UDDIN; YAZDIFAR, 2019a). Therefore, in case of better governance and high accountability, they catalyze the availability of external financing for R&D, ensuring responsible decisions, actions, and commitment to accomplishing the R&D tasks within a country (HILLIER *et al*., 2011; ALAM *et al*., 2020).

Another case of country governance lies in the political stability and absence of violence, which may strongly influence the firm's financial and investment capacity. Overall, when exists instability, frictions are likely to arise in obtaining external financing for R&D (SASIDHARAN; LUKOSE; KOMERA, 2015). For instance, when the firm operates in an unstable political environment, it deteriorates the currency in a country and difficult to financing innovative activities (ALAM; UDDIN; YAZDIFAR, 2019a). Thereby, this unstable institutional configuration typically discourages R&D and heavily draws managerial resources (BARASA *et al*., 2017).

In more extreme cases of political instability, Uddin *et al*. (2021) documented that terrorism negatively impacts innovation. The authors observed that the negative effects of terrorism are higher in developing economies than in developed countries. This is due to the strong institutional settings that provide confidence and incentives in developed countries, which permits firms to maximize innovation and minimize risks behind terrorism acts (UDDIN *et al*., 2021). In contrast, however, Tan and Chintakananda (2016) noted for 40 countries that political stability directly reduces firm performance. Although the results are rather counterintuitive, this is because excessive certainty may reduce the opportunity for development. Therefore, it seems that uncertainty may create opportunities, such as a competitive advantage for firms to enhance their growth (TAN; CHINTAKANANDA, 2016).

In the case of government effectiveness, government policy and regulations on market development are a key component of the regulatory environment of developing economies (YI *et al*., 2017). Accordingly, effective governments can provide high-quality civil services, such as education, which facilitates knowledge diffusion and human development (WU *et al*., 2016). For example, Singh and Gaur (2013) explain that in 1991, India faced a severe fiscal crisis that prompted it to undertake major economic reforms, paving the way for deregulation and privatization. Effectively, the deregulation and privatization attracted foreign players, forcing

local firms to invests in R&D to remain competitive. Similarly, Sun, Qu and Liao (2018) observed that the deregulation in the Chinese pharmaceutical sector positively impacted the R&D intensity.

In the case of the Rule of Law, it is highly expected that countries, where the rule of laws is well-defined and transparent, encourage investment, entrepreneurship, and innovative activities (WANG; KAFOUROS; YAN, 2015). In another way, firms operating in an economy with weak legislative institutions will encounter high transaction costs and high uncertainty (WU, 2013). In a more specific legal aspect, Bianchini, Llerena and Martino (2019) state that IPRs protection is positively associated with the firm innovation performance. By this means, a country environment that offers proper knowledge protection, such as well-developed IPR laws, can reduce the probability of imitation and protects their innovation output (WU *et al*., 2016).

Another important dimension of country institutions heavily relies on the levels of corruption. At this roots, corruption activities reflect the country's legal, economic, cultural, and political institutions (SVENSSON, 2005). In this specific case of governance, corruption is a phenomenon that is fairly widespread worldwide and even more frequent and intense in developing economies, which implies several consequences for the country and firms' activities (CUERVO-CAZURRA, 2016). For example, it is not rare that firms bribe government officials to grant licenses, permits, or preferential treatments in developing economies (ANDRÉS; MIN, 2020; CUERVO-CAZURRA, 2016).

Clearly, the effects of corruption on an economy are innumerous. For example, in an environment overshadow by corruption, Barasa *et al*. (2017) explain that innovators are often subjected to extortion from government officials because they require licenses and permits, which reduces a firm's potential to invest in R&D and develop innovative new products. Similarly, Alam, Uddin and Yazdifar (2019a) found that it is highly likely that corruption makes the firm's R&D investments and other innovative activity projects more uncertain and less profitable. For this and other reasons, countries with high levels of corruption harm the firm's innovation and entrepreneurial capacity (GOEDHUYS; MOHNEN; TAHA, 2016) and, therefore, downgrade the economic growth (MAURO, 1995). In the specific case of the Latin America Region, Paunov (2016) documented that corruption is a barrier to innovating in small-medium enterprises (SMEs) and lowers different types of innovation investments.

Finally, the literature explains that good regulatory quality increases the investment opportunities and helps firms with market entry and keeping up-to-date with developments (ALAM; UDDIN; YAZDIFAR, 2019a). Apart from this, the quality regulatory market has

become an essential factor for developing economies. For example, Andrés and Min (2020) found that higher regulatory quality facilitates innovation for Chinese firms. Moreover, Tan and Chintakananda (2016) documented that regulatory effectiveness directly enhances firm performance due to more enforcement and transparency. Therefore, as the regulatory environment improves, more and more industry sectors will be opened to Foreign Direct Investment (FDI), whereas the foreign entrants will face fewer formalities, permits, and licenses (MEYER *et al*., 2009).

3 METHODOLOGY AND DATA

To answer the main question and address each specific objective, it is essential to detail the methodology approach applied in each Article (1, 2 and 3). In addition, this section describes the main sources of information from Article 1 and data that compose the operationalization of each variable from Articles (2 and 3). Moreover, it describes the statistical methods and estimators and the econometric assumptions in Articles (2 and 3).

3.1 Methods – qualitative and quantitative approaches of research

Every research needs an appropriate methodology with a good plan and adequate methods to produce high-quality scientific knowledge. Accordingly, to answer the main objective and each specific one, two methodological pillars compose the structure of this thesis. In other words, the qualitative and quantitative approaches. With these two approaches, it is possible to focus on the meanings of a specific concept, plan the procedures for research, collect, analyze and interpret data (CRESWELL, 2014) and, thereby, generate scientific knowledge to explain the relationship between the observed phenomenon in a given theory.

As outlined in the Introduction, one of the contributions from this thesis comes from the literature review. The first approach, the qualitative, allows to create and define a new concept to explain how the innovation process emerges. In this case, the qualitative approach focuses on the meanings and interpretations of the concept of innovation, as proposed in Article 1.

Specifically, in the case of the literature review (Article 1), it provides a solid base to understand what is already known about a specific topic by synthesizing the recent and landmark studies in a given area (LEAVY, 2017). To enhance the understanding in using this approach, Cooper (2010) points out four types of literature review: literature reviews that (a) integrative review, what others have done and said, (b) criticize previous scholarly works, (c) build bridges between related topics, and (d) identify the central issues in a field. Thereby, literature reviews help to accomplish several research purposes.

Overall, a literature review is nothing more than “seeing what journal articles, books, and other sources argue about previous and contemporary research on the topic” (BALNAVES; CAPUTI, 2001, p. 24). Specifically, systematic literature reviews are important methods for making sense of large volumes of information (THORPE; HOLT, 2008). In addition, it supports in determining whether the topic is worth studying and provides insight into how the researchers can limit the scope to a needed area of inquiry in advancing research (CRESWELL, 2014;

GOUGH; OLIVER; THOMAS, 2012). Therefore, and although the systematic reviews seem simple, it is a key tool to manage the diversity of knowledge for a specific academic inquiry (TRANFIELD; DENYER; SMART, 2003).

The second and most predominant approach of this thesis follows the quantitative methodology. In a more profound and specific case, the quantitative approach helps to measure the research. Unlike the qualitative approach, quantitative studies can be detailed measured (BALNAVES; CAPUTI, 2001). As Lord Kelvin claimed: "When you cannot measure it when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind" (NAGAOKA; MOTOHASHI; GOTO, 2010, p. 1085). Overall, this is particularly truly accepted once a significant part of inputs and outputs from Articles (2 and 3) are derived from secondary sources of data (quantitative data). In other words, it is highly recommended to adopt statistical and specific econometric approaches to measure and analyze secondary databases.

Finally, Creswell (2014) explains that the quantitative approach is one postpositivist worldview. For instance, this distinguishing feature allows researchers to model relationships using hypotheses in quantitative social science (BALNAVES; CAPUTI, 2001; LEAVY, 2017). Therefore, this allows researchers to tests a theory by specifying hypotheses to support or refute them (CRESWELL, 2014).

3.2 Data sources

In light of the quantitative studies, this thesis uses several data sources for a country-level (Article 2) and also firm-level analysis (Article 3). The first dataset of this thesis (data for Article 2) is based on country data from RICYT, a source of information providing several indicators related to the innovative effort across several LAC countries. The main object of RICYT consists in "promote the development of instruments for measuring and analyzing science and technology in Ibero America, in a framework of international cooperation, in order to achieve a better knowledge of them and its best utilization as instruments for the decision-making process" (RICYT, 2021). Specifically, the RICYT databank accounts for relevant data of science, network and technology indicators (e.g., R&D personnel, PhD graduates, bibliometric indicators, patents granted and requested, R&D expenditures, and others).

The second source of data relies on indicators from the World Bank. This databank encompasses the World Development Indicators (WDI) – the primary World Bank collection of development indicators. According to the World Bank (2021), the "World Development Indicators is a compilation of relevant, high-quality, and internationally comparable statistics

about global development and the fight against poverty. In addition, the database contains 1,400 time series indicators for 217 economies and more than 40 country groups, with data for many indicators going back more than 50 years" (WORLD BANK, 2021).

Third, it is also selected data from the Global Competitiveness Report (GCR), annually published by the World Economic Forum (WEF). The GCR is a yearly report published by the World Economic Forum to measure a set of institutions, policies, and factors that affect an economy. After merging from multi-country sources of information (RICYT, World Bank, and WEF data), the final sample from Article 2 resulted in 15 economies from LAC countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay and the Bolivarian Republic of Venezuela. The nine-year sample period of this study extends from 2009 to 2018.

The firm-level dataset adopted in Article 3 consists of detailed financial information extracted from each consolidated annual report, starting from 2012 to 2019. The raw data is based on four unique financial data sources from the Stock Exchange and Over-the-Counter Market (financial statements) available on B3 (*Brasil, Bolsa e Balcão*), formerly the "The Brazilian Stock Exchange", *La Comisión para el Mercado Financiero* CMF from Chile, BMV Group from Mexico S.A.B. de C.V., and *Bolsa de Valores de Lima* BVL "Peru Stock Exchange". Table 1 summarizes the firm frequency by industry sector considering the 2-digit International Standard Industrial Classification of All Economic Activities (ISIC 4 rev. 4). For more detail about each firm, see Appendix A, Summary of firms by firm name, ISIC rev. 4 and country.

The second dataset from Article 3 comprises information from the Worldwide Governance Indicators (WGI). The Worldwide Governance Indicators project reports aggregate and individual governance indicators for over 200 countries and territories from 1996 to 2019 (WGI, 2020). The information reported in WGI encompasses six broad dimensions of governance: Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. In a broad sense, these six governance dimensions include several formal and informal institutions in a given country, such as "the process by which governments are selected, monitored and replaced; the capacity of the government to effectively formulate and implement sound policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them" (KAUFMANN, KRAAY, MASTRUZZI, 2009, p. 5).

Table 1 – Distribution of firms by industry sector (ISIC rev. 4 from 2012-2019).

Code	Description	Freq	%
1	Crop and animal production, hunting and related service activities	12	4.36
2	Forestry and logging	5	1.82
3	Fishing and aquaculture	6	2.18
6	Extraction of crude petroleum and natural gas	3	1.09
7	Mining of metal ores	21	7.64
9	Mining support service activities	1	0.36
10	Manufacture of food products	26	9.45
11	Manufacture of beverages	12	4.36
13	Manufacture of textiles	17	6.18
14	Manufacture of wearing apparel	8	2.91
15	Manufacture of leather and related products	2	0.73
16	Manufacture of wood and of products of wood and cork, except furniture	4	1.45
17	Manufacture of paper and paper products	4	1.45
19	Manufacture of coke and refined petroleum products	5	1.82
20	Manufacture of chemicals and chemical products	21	7.64
21	Manufacture of pharmaceuticals, medicinal chemical and botanical products	7	2.55
22	Manufacture of rubber and plastics products	3	1.09
23	Manufacture of other non-metallic mineral products	24	8.73
24	Manufacture of basic metals	21	7.64
25	Manufacture of fabricated metal products, except machinery and equipment	8	2.91
26	Manufacture of computer, electronic and optical products	3	1.09
27	Manufacture of electrical equipment	6	2.18
28	Manufacture of machinery and equipment n.e.c	3	1.09
29	Manufacture of motor vehicles, trailers and semi-trailers	9	3.27
30	Manufacture of other transport equipment	5	1.82
31	Manufacture of furniture	2	0.73
32	Other manufacturing[(a)]	2	0.73
36	Water collection, treatment and supply	1	0.36
38	Waste collection, treatment and disposal activities	1	0.36
43	Specialized construction activities	2	0.73
49	Land transport and transport via pipelines	2	0.73
50	Water transport	3	1.09
52	Warehousing and support activities for transportation	2	0.73
61	Telecommunications	10	3.64
62	Computer programming, consultancy and related activities	6	2.18
99	Multiple activities [(b)]	8	2.91
Total		**275**	**100**

Note: Freq. = frequency. [(a)] Manufacture of jewelry, bijouterie and related articles; Manufacture of jewelry and related articles; Manufacture of imitation jewelry and related articles; Manufacture of musical instruments; Manufacture of sports goods; Manufacture of games and toys; Manufacture of medical and dental instruments and supplies; Other manufacturing n.e.c. (not elsewhere classified); [(b)] includes manufacturing industries with diversified in several ISIC codes present in the table and includes division 46: Wholesale trade, except of motor vehicles and motorcycles.

Finally, the information reported in monetary values is collected based on the country currency (e.g., Nuevo Soles, Pesos, BRL) or, at the very least, based on the international standards (US$). As a result, standardization is necessary. Therefore, all reported values that are different from the international standard were converted into millions of US dollars. Considering the 2-digit ISIC code (ISIC 4 rev. 4), the firm-level panel data for Brazil, Chile, Mexico and Peru include firms from several manufacturing sectors. The final sample of Article 3 consists of 275 firms, extending from the year 2012 to 2019.

3.3 Model – Statistical estimators

This thesis adopts the panel data because it allows obtaining an efficient estimation of the effects from each explanatory variable. The use of panel data results in more informative data, reduces the collinearity issues among variables, and has more degrees of freedom (BALTAGI, 2013; WOOLDRIDGE, 2002). More specifically, the thesis considers the Arellano–Bond (ARELLANO; BOND, 1991) and the augmented versions, Arellano–Bover/Blundell–Bond for the dynamic panel estimator (ARELLANO; BOVER, 1995; BLUNDELL; BOND, 1998; BLUNDELL; BOND, 2000). These estimators adopt the lagged dependent variable to control for endogeneity problems in the presence of serial correlation between the explanatory variable and the error term (WOOLDRIDGE, 2002).

Accordingly, the best estimator was carefully chosen, seeking the most efficient result. The first estimator is based on Generalized Moments Method – GMM introduced by Lars P. Hansen (1982). The GMM estimator had become a very popular estimator among empirical researchers (BALTAGI, 2013; BAUM; SCHAFFER; STILLMAN, 2003) and is superior over the Ordinary Least Squares (OLS) and Fixed Effects (FE) estimators in many cases (ARELLANO; BOVER, 1995; BAUM; SCHAFFER; STILLMAN, 2003).

For example, the first advantage consists of the size of the sample and the time period of analysis, i.e., data from Article 3. This is because the GMM estimation is largely recommended when the panel data have many individuals ($t \leq n$) but few observations overtime periods (BLUNDELL; BOND 1998; ROODMAN 2009a). Second, the OLS never consistently estimates the coefficient of the lagged dependent variable unless there is no heterogeneity in the panel (WOOLDRIDGE, 2002). In the case of the fixed-effect estimator, it is necessary to assume that all variables are exogenous, which is not the case, once some variables are predetermined or strictly endogenous. Thus, using GMM with the Arellano-Bond conditions

has wider applicability and robustness than OLS and FE (WOOLDRIDGE, 2002; ROODMAN, 2009b).

The third advantage in the use of the GMM estimator lies in the heteroskedasticity and autocorrelation issues, an omnipresent problem in empirical works (BAUM; SCHAFFER; STILLMAN, 2003). Thereby, when GMM uses the lagged values of the explanatory variable it becomes more efficient and robust in the presence of heteroscedasticity and autocorrelation within individuals (ARELLANO; BOND, 1991; HANSEN, 1982; ROODMAN, 2009a). For instance, heteroscedasticity may arise due to differences of unobserved country heterogeneity, implying residual outliers across observations (ALAM; UDDIN; YAZDIFAR, 2019a).

Specifically, the original GMM estimator is referred to difference GMM while the Arellano–Bover/Blundell–Bond estimator augments Arellano–Bond has an additional assumption that the first difference of instrument variables are uncorrelated with the fixed effect (ARELLANO; BOND, 1991; ARELLANO; BOVER, 1995; ROODMAN, 2009a). Thus, difference GMM corrects endogeneity transforming all regressors, usually by differencing them and removing the fixed effect (ARELLANO; BOND, 1991; HANSEN, 1982). Nonetheless, difference GMM remains poorly and biased when the independent variables are persistent over the time (BLUNDELL; BOND, 1998). Alternatively, system GMM, Arellano and Bover (1995) and Blundell and Bond (1998), introduce more instruments to improve the efficiency and transform the instruments to make them exogenous with the fixed effects. In short, the two-step[4] option is a more robust and efficient estimator than the one-step once it addresses the proliferation of instruments.

Although this implicates efficiency, a large number of instruments may result in over-identification of instruments. For this reason, Roodman (2009a; 2009b) suggests the collapse[5] sub-option to limit the proliferation of instruments and to prevent an over-fitted model. To check the validity of instruments, the difference-in-Hansen test of the joint significance of the instruments consists of the null hypothesis that the additional instruments are valid (HANSEN, 1982). Thereby, the presence of valid instruments subset means they are uncorrelated with the composite error term. In other words, the validity of instruments by the Hansen Test is necessarily in the case of dynamic system GMM. Finally, the use of *xtabond2* Stata modulate

[4] The two-step estimator adopts the consistent variance-covariance matrix from the first-step estimator GMM (BALTAGI, 2013).

[5] The collapse sub-option creates one instrument for each variable and lag distance, rather than the un-collapsed form, in which each instrumenting variable generates one column or each time period and lag available to that time period (ROODMAN, 2009b).

(ROODMAN, 2009b) implements both estimators with the Windmeijer (2005) correction[6] for a finite-sample correction (two-step estimation and vce robust errors options).

Regarding Article 2, it follows a different estimator. Once variables do not indicate issues of heteroskedasticity and autocorrelation, the random-effect Generalized Least Squares (GLS) regression seems an appropriate solution. Nonetheless, there is still a possibility of another econometric issue appear (i.e., endogeneity) because the main variable of interest is predetermined by the regressors. In this particular case, two-stage least squares (2SLS) and the use of Instrumental Variables (IV) is an option to mitigate problems of endogeneity. To check endogeneity, tests such as Durbin (1954), Wu (1973) and Hausman (1978), known as the Durbin-Wu-Hausman (DWH) for the augmented regression are adopted. Finally, the Basmann (1960) and Sargan (1958) chi-squared tests enable checking the overidentifying restrictions of instruments.

Ultimately, this thesis adopts other equally important statistical procedures, which allow to enrich the analysis, maintain the quality and robustness of the results. For example, considering the data in Article 2 and Article 3 show high multicollinearity (near perfect linear relationship) between explanatory variables, it is was necessary to conduct the variance inflation factor (VIF) test. Hair *et al*. (2010) and many other researchers recommend this approach to check if 1/VIF values are greater than the threshold limit of 10. Finally, to rule out specific cases of multicollinearity, the Principal Component Analysis (PCA) was adopted. This method originated in the work of Pearson (1901) and Hotelling (1933), with the main objective to combine variables with great variance into a single component index. Therefore, this procedure allows to address the collinearity between variables and, at the very least, increase the interpretability and robustness of results.

[6] Windmeijer (2005) proposed a standard error correction by estimating it in a two-step, without a downwards biased standard error. Therefore, the two-step system GMM with the Windmeijer (2005) correction results in asymptotically robust standard errors. In addition, the correction by Windmeijer (2005) employs orthogonal deviations to maintain the fine-sample size in unbalanced panels and, at the same time, controls the instrument matrix (ROODMAN, 2009b).

3.4 Summary of the thesis' methodology

Considering the foregoing methodologies, it is necessary to stylish a logic sequence in this thesis. Additionally, and by its nature, all Articles (1, 2, and 3) are empirical. Table 2 briefly describes the research type adopted, main objective, database and the theory adopted in each empirical Article.

Table 2 – Summary of the methodology by each empirical Article.

#	Research type	Objective	Database	Theory
Article 1	Empirical: Systematic Literature Review	Investigate and shed light about innovation and R&D across manufacturing industries in Latin America and the Caribbean countries	Secondary database: ISI – Web of Science; Scopus (Elsevier B.V) and Taylor & Francis 1945-May 2020	Innovation / institutional theory
Article 2	Empirical: Econometric (GLS, 2SLS – IV)	Examine how the role of country intellectual property rights protection affects innovation performance	Secondary database: RICYT, WDI, WEF, WTO, USTR, IBRD/IDA 2006-2018	Innovation / institutional theory
Article 3	Empirical: Econometric (GMM – IV)	Explore how the firm's R&D performance is moderated by the relationship between R&D investments and the role of country institutions in Latin America	Secondary database: Annual financial datasheet from Brazil, Chile, Mexico and Peru, 2012-2019	Innovation / institutional theory

Source: The Author.

4 SUMMARY OF CONCLUSIONS

The summary of conclusions briefly recapitulates the background of the thesis and highlights the main research findings from each Article (1, 2, and 3). Further, it describes the main policy and practical implications, and also the limitations. Finally, the conclusion ends this thesis.

4.1 Briefly background of the thesis

In retrospect, R&D is an invaluable knowledge activity mainly held by firms from advanced economies. Thereby, R&D is also necessary for developing economies to achieve the technological frontier, and therefore, reduce poverty and increase wealth (CRESPI; ZUNIGA, 2012; OLAVARRIETA; VILLENA, 2014). Nonetheless, investing in R&D might be challenging or, at the very least, difficult for developing economies due to their high-risk nature and long-term return (ALAM; UDDIN; YAZDIFAR, 2019a; KAFOUROS, 2008, HILLIER *et al*., 2011; UN; MONTORO-SÁNCHEZ, 2011). In addition, developing economies are constantly surrounded by several institutional issues (HOSKISSON *et al*., 2000; MEYER; PENG, 2016; SINGH; GAUR, 2013; WU; WU; ZHUO, 2015), which means their institutional quality or development may foster or harm this knowledge activity.

Prior research documented the effect of institutions on the firm's R&D investments across developing and transition economies (ALAM; UDDIN; YAZDIFAR, 2019a; 2019b; BARASA *et al*., 2017). Nonetheless, little is known about how institutions affect the R&D investments across LAC countries. Therefore, building on the institutional theories (NORTH, 1990; 1991), and assuming that "institutions matter" to support innovation activities and economic growth (ACEMOGLU; JOHNSON; ROBINSON, 2005; ACEMOGLU *et al*., 2019; SUN; QU; LIAO, 2018), this thesis examined how formal and informal institutions directly impacted the innovative performance across several countries in LAC countries.

Through a systematic literature review and using extensive country- and firm-level panel data analysis, it was possible to understand and answer the main research question*: What is the effective condition of R&D investments and innovation performance in Latin America and Caribbean countries and how formal and informal institutions affect the firm's and country's innovation performance?* This thesis developed a punctual and detailed analysis based on three empirical Articles (1, 2, and 3) to enhance the understanding of innovation and

institutions in LAC countries. Taken together, the following section recapitulates the main remarks of each Article (1, 2, and 3) to answer the main research question.

4.2 Summary of the main research findings of the thesis

Article 1 was the first empirical study from this thesis with the main objective to investigate and shed light about innovation and R&D across manufacturing industries in Latin America and the Caribbean countries. Building on a deep systematic review, it was possible to understand the history and antecedents of innovation policy and development across Latin American countries, the benefits, and also the main challenges to foster and maintain innovative and other knowledge activities. Furthermore, through a careful content analysis of past scientific publications on innovation and R&D in LAC, it was possible to understand the innovation scenario and inform several contributions.

Overall, the findings suggested that research on innovation in Latin countries mainly applies the CDM approach to check and measure innovation propensity, assess the R&D intensity, and therefore, firm productivity (CHUDNOVISKY, LÓPEZ; PUPATO; 2006; CRÉPON; DUGUET; MAIRESSE, 1998). These studies primarily contributed using specific microdata files usually adopted to assess the firm innovation, R&D intensity and productivity. This opened an alternative route to explore a novel source of data and test a new approach to assess the firm's R&D investments and performance, as implemented in Article 3.

Concerning the context of innovation in LAC, it was possible to observe that R&D-intensive industries are mainly carried out by large companies. Furthermore, the innovation activities are usually predominated through imports of technology aiming the short-term results. In other words, the virtuous circle of innovation and R&D investments that occur in developed economies (KAFOUROS, 2008; MAIRESSE; MOHNEN 2010; ROMER, 1990) assumes the vicious circle of innovation based on imports of technology from advanced economies by Latin American countries (FRANK *et al*., 2016; GOEDHUYS; VEUGELERS, 2012; TAVEIRA *et al*., 2019).

This insight was also documented in Article 3, which suggests that Latin American countries mainly shown a short-term R&D performance. Overall, this means that why firms show only the capability to reproduce technologies and products already existent in the market (DUTRÉNIT *et al*., 2019). Nonetheless, this result varies and cannot be generalized to all developing economies once some countries show positive (MUINELO-GALLO; MARTÍNEZ,

2018) and, at the same time, negative results by importing technology from developed countries (CHUDNOVISKY, LÓPEZ; PUPATO, 2006; FERNÁNDEZ; GAVILANES, 2016).

Extending the findings to the institutional theory, the issues are countless. The empirical analysis showed that LAC countries lack institutional quality aiming to foster innovations, which in some cases worsens across the decades (ALCORTA; PEREZ; 1998). In a more specific legal aspect of institutions, the intellectual property rights protection still lacks in quality, revealing a weak and undeveloped patent protection system to foster local and foreign innovation activities (PÉREZ *et al*., 2018).

Article 2 examined how the role of country intellectual property rights protection affects innovation performance. This study showed how the IPRs protection interacts with the domestic and foreign innovation base activities. To assess the IPRs' effects, it was developed a unique IPR protection index for 15 LAC countries. Specifically, following the methodological approach of Khoury and Peng (2011), we added to the literature a new index, the foreign innovation base index.

The results showed that both domestic and foreign innovation activity contributes to the country's innovation performance, albeit they notably follow a distinct trajectory in the presence of strong IPRs protection. First, past studies commonly argued that developing economies do not have enough innovation capacity to develop and sustain significant innovation performance (STEL *et al*., 2019; SWEET; MAGGIO, 2015). Differently, it was possible to observe that IPRs partially strengthen the country's innovation performance.

Nonetheless, this result is not simple *per se*. For instance, when the country's IPRs protection increase and interact with the domestic base innovation, the local innovation performance showed a U-shaped pattern. Not surprisingly, this result strongly suggested that developing economies do not have sufficient knowledge and absorptive capacity to take advantage of increases in IPRs strength. Put in another way, domestic innovation activity mainly relies on copying and imitative skills, which means local firms may not appropriate the benefits of high IPRs systems.

Second, the foreign innovation activity acts as a second arm for developing economies. This is because foreign capital brings advanced knowledge and technology spillover to other industries in the host country. In this case, there is no doubt that the foreign presence increases the host country's innovation performance. The results indicated this and more. Unlike domestic activity, the country innovation performance showed an inverted U-shaped pattern when the foreign innovation interacts with high IPRs protection. In other words, as the IPRs

protection increases, foreign investors are challenged to develop their innovation activities in a given country.

Third, the coefficients for domestic and foreign innovation activity do not rise to a similar degree. While the domestic innovation activity showed a higher coefficient, the U-shaped pattern perhaps suggests a considerable variation between the type of innovation produced by the domestic and foreign activity. Again, this is because the inverted U-shaped pattern is a strong sign that foreign actors are more prone to generate meaningful innovation and deal positively in the presence of high IPRs protection in a given country.

Article 3 explored how the firm's R&D performance is moderated by the relationship between R&D investments and the role of country institutions in Latin America. Using data from 275 Latin American firms, it was applied the system GMM estimator with instrumental variables (IV). Since then, this is the first attempt to extend the literature of R&D in Latin American countries considering exclusive financial data to investigate the impact of the role of institutions on firm's R&D performance.

Moreover, Article 3 showed a novelty contribution to innovation literature, once firm-level data is scarce across Latin American countries. The results enrich the literature on economic institutions (NORTH, 1990) considering several formal and informal institutions that may impact the firm activity (DUNNING; LUNDAN, 2008a; CANTWELL, DUNNING, LUNDAN, 2010). Moreover, the findings contributed with past research to understand the relationship between a firm's R&D investments and institutions in developing economies with new and interesting insights (e.g., ALAM; UDDIN; YAZDIFAR, 2019a; 2019b; BARASA *et al*., 2017).

Considering formal and informal institutions is useful to scrutinize the impact of each country's governance institutional structures on the firm's R&D investments. Thereby, a key insight is that country's institutions, such as regulatory quality, political stability, voice and accountability, positively influence the firm's R&D investments. Although these institutions have positively moderated the relationship between a firm's R&D investments and performance, the empirical results also suggested a negative effect when government effectiveness interacted with the firm's R&D investments.

Moreover, and different from Alam, Uddin and Yazdifar (2019a) and Alam *et al.* (2020), it was observed that Latin firms only showed a short-term R&D performance. Contrary to the assumption that "institutions matter", the results suggested that the country's institutions are not sufficient developed to support the long-term R&D performance. A potential explanation

of this result is that, perhaps, institutions are well-developed, but only aiming for a short-term R&D performance.

The result from this specific research is directly related to other studies (e.g., VIGLIONI; BRITO; CALEGARIO, 2020; VIGLIONI; CALEGARIO; 2020). In addition, the findings also complement Article 2, which suggested that Latin firms cannot sustain high IPRs regimes, and, thereby, do not invest in innovative activities to consider a high IPRs policy. This makes an important contribution to the innovation and institutional theories. From a short-term performance perspective, "institution matters", albeit the results suggests that institutions are not sufficiently advanced to support long-term R&D performance. This counterargument is very thought-provoking for policymakers. In other words, this finding is of particular interest to policymakers and plays a significant policy implication that is discussed in the following section.

4.3 Policy and practice implications

The findings of this thesis offer potentially promising implications for policymakers and practitioners. First, through a systematic literature review, it was possible to contribute with the future research directions and challenges to develop and foster knowledge activities, such as R&D in LAC countries. In addition, the findings are of particular relevance for policymakers. Although Latin countries are investing in R&D, the scale of investments is lower when compared to developed and transition economies. This is also of particular interest to large multilateral bodies that aim to foster the development of LAC countries (e.g., Inter-American Development Bank – IADB/IDB, World Bank, Economic Commission for Latin America and the Caribbean – CEPAL). Therefore, it is necessary to develop modern initiatives to foster R&D in Latin economies.

Analyzing a more specific institution – the country's intellectual property rights, in Article 2, it was possible to identify several policy implications. By investigating two different types of sources of innovation within a country – by domestic and foreign innovation base activity – the research provides information to policymakers about the effects of increasing the country's IPRs protection. The findings showed that not only domestic activity increases the country's innovation performance but also foreign innovation. At first glance, the findings seem rather simplistic. Nonetheless, in terms of policy implications, they are complex for the following reasons.

First, although domestic innovation activity showed positive in the presence of the country's IPRs, the innovation performance assumes a U-shaped pattern. One possible explanation is that developing economies lack knowledge and absorptive capacity to benefit from increases in IPRs protection (STEL *et al*., 2019; SWEET; MAGGIO, 2015). For this reason, it is crucial to consider investing and developing innovation base activities, for example, increase the quality of education (COE; HELPMAN; HOFFMAISTER, 2009; KHOURY; PENG, 2011; VARSAKELIS, 2006). Such investment plays an important role in generating knowledge and scientific labor in a given country to stimulate the patenting of new inventions. Moreover, this ability allows countries to go beyond the passive strategy of merely copying and imitating innovations.

Second, for the foreign innovation activity, results clearly showed the opposite. When the foreign innovation activity interacted with the country's IPRs protection, the country's innovation performance showed an inverted U-shaped relationship. In other words, at a certain threshold, increases in the country's IPRs protection are desirable for foreign innovation activity. In terms of policy implications, the equilibrium is desirable because there is no doubt that foreign investors, especially firms from the technology-intensive, heavily take advantage of the host country's IPRs (MASKUS *et al*., 2019; SMARZYNSKA-JAVORCIK, 2004). Therefore, policymakers must develop an IPRs policy that supports a "moderate" IPR protection (FURUKAWA, 2010; LIU; LI, 2019). In other words, policymakers must carefully weigh and balance the IPRs mechanism for both domestic and foreign innovation base activity.

Regarding other IPRs institutions, such as USTR "Special 301", the findings vaguely showed a signal of relevance from these institutions on the domestic innovation activity. Even though this result showed low support for the analysis, this finding is of particular interest to policymakers. Overall, informal institutions, such as the USTR "Special 301" underline multiple country's IPRs deficiencies. For this and other reasons, and in line with Christopoulou *et al.* (2021), we believe that the quality of *de facto* enforcement "Law in practice" should bring better results to a country than *de jure* legal protection "Law on the books", such as TRIPS agreement. Perhaps, this can be seen as indicative that better law enforcement may yield more positive effects on changes in the country's IPRs. Specifically, policymakers should consider and follow the instructions from informal agencies, such as the USTR "Special 301", rather than merely signing formal international agreements and fail to follow basic statements.

As shown in Article 3, the literature suggested that "institutions matter" for support innovation activities. As part of country institutions, policymakers need to develop their sense of commitment to improve the country's institutions. Accordingly, managers can safely double

down the sheer amount of R&D aiming the long-term innovative activities. Therefore, public support and market reforms are critical to making it happen.

In terms of practical implications, while institutions as the "rules of the game" change and affect the firm's environment – the reciprocal idea that firms can change the institutions is also truly acceptable (CUERVO-CAZURRA; MUDAMBI; PEDERSEN, 2019). Far from isolated, this interchange between practitioners and policymakers is crucial to empower an innovative economy. Thereby, a clever and wise start point is to inform practitioners, such as corporate managers, to push forward policymakers in changing the country's institutions in favor of R&D investments. All in all, it is wiser to consider both sides as weighted peers. Therefore, instead of breaking interests into different parts, better yet is combines them to improve the long-term R&D activity in developing economies from Latin America.

4.4 Limitations and directions for future research

Although this thesis is not free of limitations, it opens multiple research avenues to continue paving the road of innovation in LAC countries. While Article 1 has been carried out by the so-called state-of-the-art, it is still not free of limitations. Building on the systematic literature review it was not possible to search and find all related studies to innovation and R&D topics in LAC countries. First of all, it was impractical to search in all electronic scientific bases since they are numerous.

For this and other reasons, future studies still need to continue this type of analysis to find other research not documented in Article 1. Although this research followed a recent approach to search peer-reviewed articles (e.g., VRONTIS; CRISTOFI, 2021) future research should continually push the creativity to design a new method of searching and classifying papers. To increase the quality of analysis, it would be very interesting to consider other scientific electronic outlets and also specific searches on journals of business and management, such as *Academy of Management Journal* (AMJ), *Academy of Management Review* (AMR), *Administrative Science Quarterly* (ASQ), *Journal of International Business Studies* (JIBS), *Journal of International Business and Policy* (JIBP), *Organization Science* (OS), *Organizational Research Methods* (ORM), *Management Science* (MS), *Strategic Management Journal* (SMJ), *Management International Review* (MIR), *Journal of World Business* (JWB), *International Business Review* (IBR), and others.

Second, future research should continue to exploit the philosophical and creative process to develop even more elaborated studies. Although the research adopted the

philosophical and scientific approach in explaining how innovation emerges, it is suggested that future works add the proposed approach as a starting point to create a brand new one. Third, once innovation in Latin America is still in progress with mixed kinds of studies, future research should extend studies in LAC countries addressing sub-areas of research topics in innovation and R&D. As such, it would be interesting to consider a systematic literature review, for example, on innovation in MNEs, sustainable innovation, innovation in SMEs, innovation by export, entry mode, innovation in state-owned enterprises, business group affiliation, geographic dispersion and R&D location choices as well as so many other topics.

As shown in Article 2, it was observed a methodological limitation. Unlike OECD and Asian countries, in Latin America, the information on R&D expenditures, the number of registered patents, and other kinds of information is not documented by all parties, resulting in large missing data across several Latin countries. Unfortunately, due to the unavailability of data, it was not possible to account for all Latin economies in the macro-level analysis. Future studies should consider other free access or even private databases to enrich the empirical literature across Latin America.

Moreover, to account for the IPRs protection effects it was adopted macro-level data rather than a micro-level one. In Article 1 (see VIGLIONI; BRITO; CALEGARIO, 2020), the authors discovered and suggested assessing the firm's innovation and R&D investments in low and high IPRs configurations. Nonetheless, once patent data at the firm level is very scarcer in LAC countries, if unavailable, it was not possible to contribute to this analysis. Subsequently, researchers should consider this kind of data to assess whether the institutional context of IPRs affects the firm innovation performance measured by patent output.

Another limitation is associated with the measurement of intellectual property rights protection. Although Article 2 was built based on a unique index (IPRPI) in line with the institutional Pillar from the Global Competitiveness Report, it may narrow the analysis or even not capture all IPRs protection in a given country. In light of this limitation, future research could further investigate the IPRs context considering other indexes, such as the classic "International patent protection index" from Park (2008), the "international patent systems strength" proposed by (PAPAGEORGIADIS; CROSS; ALEXIOU, 2013), and the more recent "Patent enforcement index" from Papageorgiadis and Sofka (2020). Nonetheless, and as mentioned in Article 2, it was not possible to consider the former methodology due to the range of years of Park's IPRs index (1960-2005). While the first does not reflect the temporal reality of our research scenario, the two latter approaches are due to the data restriction and availability to develop both indexes.

Although it is challenging to work on the composition of the IPRs index proposed by (PAPAGEORGIADIS; CROSS; ALEXIOU, 2013; PAPAGEORGIADIS; SOFKA, 2020), this simply does not exclude the possibility of future research consider these indexes in an attempt to evaluate IPRs effects in the context of LAC countries. Additionally, although Park's (2008) index is still outdated, the index is one of the most comprehensive to reflect the strength of IPRs in a given country. Specifically, future research should continue to consider the "Law on the books" and "Law in practice", once there are a few limited numbers of studies adopting these formal and informal institutions (e.g., PAPAGEORGIADIS; CROSS; ALEXIOU, 2013; PAPAGEORGIADIS; McDONALD, 2019; SMARZYNSKA-JAVORCIK, 2004). Both institutions are valuable, albeit their results are still unclear. On the one hand, "Law on the books" brings several direct implications to IPRs to their followers. On the other hand, "Law in practice" results in indirect restrictions due to the lack of law and enforcement on the country's IPRs protection. Therefore, it is highly recommended that future research scrutinizes these formal and informal institutions and monitor their effects.

Ultimately, in Article 3, it was possible to observe a methodology limitation. First, the empirical analysis of 275 firms from 2012 to 2019 considered only four Latin countries (Brazil, Chile, Mexico and Peru). This is because not all Stock Exchanges of Latin America show open financial reports for all companies. In other words, it is necessary to contact local government authorities for the assessment of such data. In addition, some Latin countries are small and consequently show a very low number of companies listed on their Stock Exchange. Following past research recommendations to avoid a biased analysis, a minimum limit of firms by country was established in the analysis. Future research should access data from other Latin economies to build a more comprehensive sample to assess how the institutions affect the firm's R&D investments.

Another limitation is related to R&D investments data in Latin America. It is necessary to keep in mind that this information is highly restricted and confidential to local government agencies. In general, access the R&D dataset demands time and it is accompanied by a high bureaucracy procedure. For this reason, it was adopted one proxy for R&D (KAFOUROS, 2008). Although this methodology is in line with the definition of R&D in the "Frascati manual: Guidelines for Collecting and Reporting Data on Research and Experimental Development", this does not exempt future research to give a step forward considering more detailed data of firm R&D expenditure.

Nevertheless, and albeit past research has widely adopted the WGI governance indicators to assess the effects of institutions on R&D investments (e.g., ALAM; UDDIN;

YAZDIFAR, 2019a; 2019b, ALAM *et al*., 2020; BARASA *et al*., 2017), the use of these indicators implicates in high multicollinearity. As discussed, this is due to the similarities in the construction of each indicator (KAUFMANN, KRAAY, MASTRUZZI, 2011). Although the past mentioned researches adopted a robust estimator (system-GMM) with instrumental variables (IV), it is necessary to be cautious because some misty degree of multicollinearity may persist. In this case, even using two-step system GMM with the Windmeijer (2005) correction, the doubt hovers over the multicollinearity.

To address this issue, it was proposed and developed three sub-area indexes based on Kaufmann, Kraay and Mastruzzi (2011). Nonetheless, future research should select other institutional indicators as well as new methodological approaches. Taking advantage of this thought, it was also observed essential points not addressed in this thesis that should be explored in more detail in future research related to investments in R&D and its interaction with other institutions in LAC countries. The first consists of considering other more specific institutional dimensions (e.g., religion, culture, language, politics, and others). Therefore, more specific and regional institutions may provide useful and complementary results to understand the R&D investments carried out by firms in Latin America.

Second, supposing that institutions are not sufficiently advanced to hold a long-term R&D performance, it is strongly recommended to future research explore how companies achieve a relatively higher level of innovation (e.g., investing in R&D) in face of several institutional failures. Following this line, future research should investigate more the context of group-affiliated firms to finance R&D activities (CASTELLACCI, 2015), which is under-researched (VIGLIONI; BRITO; CALEGARIO, 2020). This topic could reveal striking results related to the institutional environment, for example, because the group-affiliated firm's "ecosystem" is common in Latin countries, such as Mexico and Chile.

Third, if unexpectedly institutions are insufficient to hold a long-term R&D performance, future research should consider if this phenomenon is related to the firm location. In other words, future research should investigate the case of agglomeration and R&D location choices in Latin America. Geographic agglomerations (regional innovation ecosystem) that occur in specific regions and large cities with heavy infrastructure investments, a large number of firms focused on technology and R&D, might be an example. This is necessary, perhaps because "institutions matter" for more specific locations. Indeed, the agglomeration of firm R&D activity is still a hot topic when it comes to empirical and theoretical development in developing economies. For scholars looking into the agglomeration of R&D, it would be valuable to check the fundaments behind the firm agglomeration and the institutional effect in

Latin America. Nonetheless, in developing economies (e.g., LAC countries), this topic is even less common, or, at the very least, it was not yet explored due to the lack of information and data.

Finally, a specific and promising future direction is related to institutions and R&D applied to sustainable innovations. This is a recent and very little explored topic regarding LAC countries. Future research should investigate and explore more the field of R&D and sustainable innovations adding the institutional dimensions to assess the firm innovation performance. Such analysis is recommended once LAC countries, such as Brazil, shown national and international recognition in industries from agrotechnology, biochemistry, and renewable energy production, that demand considerable R&D expenditures. These topics deserve special attention because sustainable innovations are gaining meaningful endorsement in the eyes of the best policymakers and world leaders, with a quick countdown to change the world landscape.

4.5 Conclusions

As a whole, this thesis sought to understand the effective condition of R&D investments and innovation performance in Latin America and Caribbean countries and the effects of formal and informal institutions on the firms' and country's innovation performance. As observed, R&D investments allow firms to access new technologies and develop knowledge activities to foster economic growth. However, Latin countries still lack knowledge activities in many ways. It is observed that, albeit all of Latin America's greatness, the region revealed difficulties in sustaining investments in R&D, as well as a good innovation performance. This means that Latin Region still has a long way to paving the road of innovation. Widely, there are many gaps to be filled and developed (e.g., institutional condition) in the scope of investments in R&D in Latin American countries.

Regarding institutions, they play as a crucial factor to support innovative activities through R&D investments around the world. Nonetheless, innovative activities in Latin American follow a different path to foster R&D activities. Overall, the literature argued that investments in innovation through R&D activities in LAC countries are mainly from developed economies through imported technology. Indeed, Latin countries still suffer from an old policy based on imports of technology. In other words, it is difficult to develop their own technologies to sustain basic innovative activities. Moreover, LAC countries heavily rely on copying and imitate foreign technology. In straightway, if LAC countries really want to achieve a higher

innovation performance, it is time to broke this old pattern and put more effort into knowledge activities.

The behavior of just import innovation and invest small amounts of R&D revealed just one of the many and true institutional faces of LAC countries. With a myriad of challenges that affect the local innovation performance, Latin countries still show high difficulty in fostering their innovative activities through the number of applied patents. As well as the patents, the number of scientific publications is still low to increase the innovation base activities in Latin economies. Many of the issues that have impacted the R&D investments are directly related to local institutions. As described along with this thesis, "institutions matter" to foster and sustain innovative activities. This thesis found this and more. The results documented that the firm's R&D investments shown a short-term performance, while it fails to sustain a long-term R&D performance. Fortunately, the findings highlight that the country's institutions are directed related to long-term R&D investments.

Accordingly, institutions such as voice and accountability political stability, and regulatory quality play an important role in fostering firm R&D investments. While there is widely accepted that "institutions matter" in fostering innovation activities in advanced economies, the same is fundamentally observed in developing countries from Latin America. In terms of policy implications, policymakers must develop and align the country's institutions to foster long-term growth. However, this mission is technically challenging in LAC countries. Policymakers need to focus more on the global development of the country's institutions and stop playing antiquated politics, and solely law on the books to foster the innovation performance in LAC countries. Thus, as a good reminder, it is important to go beyond and design modern initiatives and more aligned policies for Latin America's innovation issues. However, market reforms aiming at R&D investments in LAC countries are long overdue, which means there is a lot of room to improve. Thereby, it is necessary that policymakers make more effort to rediscover the true meaning of development when it is claimed that "institutions matter".

Finally, although this thesis showed positive results, the negative ones are also evident. Somewhat, the latter exists to show what we should develop and improve. Thereby, this thesis provided relevant scientific information for policymakers and managers. Developing institutions, and simultaneously the investment in more knowledge activities in Latin American economies, is critical to achieving long-term innovation performance. Again, "institutions matter" and fundamentally plays a role in foster innovative activities. Towards innovation, policymakers, managers, and academics still have a still have a challenging and long way to go

to paving the road of innovation in LAC countries. Therefore, it is paramount to foster firms' knowledge inputs and outputs to generate wealth and reduce poverty at levels that would not possible or imaginable in the 21st century.

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PART TWO – ARTICLES

In the remainder of this thesis, Part Two is composed of each empirical Article (1, 2 and 3). Each Article is developed in line with the journal guidelines that were submitted. Article 1 was published on *Scientometrics* (E-ISSN: 1588-2861) and, thus, follows this journal guidelines. Articles 2 and 3 are under review and, for this reason, respect the journal guidelines that were submitted. Detailed information of each Article is described on its respective cover page for authors.

ARTICLE 1 – INNOVATION AND R&D IN LATIN AMERICA AND THE CARIBBEAN COUNTRIES: A SYSTEMATIC LITERATURE REVIEW

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Innovation and R&D in Latin America and the Caribbean countries: a systematic literature review

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Abstract

After the groundbreaking works of Joseph Schumpeter, a burgeoning literature related to innovations emerged. As works in this tradition have progressed, the innovation literature has recognized that the keystone to stimulate innovation across all economies relies on Research and Development (R&D) activities. As well occur in all modern economies, innovation and R&D have drawn the attention of the academic literature and governments in Latin America and the Caribbean countries (LAC). However, the process of innovation and R&D investments in LAC have different signatures, which may result in a complex and fragmented literature. As a novelty, this research explains how innovation and R&D are fundamental in modern times and brings new systematic literature review of the state-of the-art in innovation and R&D in manufacturing industries across LAC. The results suggests that the LAC has great challenges and opportunities. The review demonstrates that after decades of investment, innovation and R&D gains prominence and firms invest more on these activities. However, the development and investment in these activities, especially considering the government support and firm cooperation are frustrating when compared to OECD countries and Asian Tigers' economies, and yet much remains to be done by the governments.

Keywords Integration review of pre-existing approaches · Innovation and R&D · Latin America and Caribbean countries · South America.

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Introduction

Innovation researches have emerged quickly and significantly as a topic of interest in areas, such as management, business and economics scholarship in the last decades. A very broad range of traditions in the field of innovation has repeatedly recognized the Research and Development (R&D) as the prime determinant element of technological innovation, since the groundbreaking work of Schumpeter (1942) "*Capitalism, socialism and democracy*", Solow (1956) "*A Contribution to the theory of economic growth*", Griliches (1979) "*Issues in assessing the contribution of research and development to productivity growth*" and Romer (1990) "*Endogenous Technological Change*". After the milestone's contributions of the past literature, a burgeoning contemporaneous literature was increased and established on the innovation and R&D fields. As such, Schumpeterian research has extensively investigated the role of innovation (Castellacci and Natera 2016). Indeed, there is no doubt that innovation is a fundamental pillar of economic growth (Mardones and Zapata 2019). In recent decades, innovation and R&D have become widely recognized as key factors affecting the competitiveness of firms and countries (Cassiolato and Lastres 2000; Goedhuys and Veugelers 2012; Milesi et al. 2013). Until now, economies are forcefully knowledge based, and innovation and R&D are the key drivers of national development, and long-term economic growth (Kafouros 2008).

Research evidences on the virtuous circle in innovation and R&D can been found in several studies of industrialized countries (Romer 1990; Griffith et al. 2006; Kafouros 2008; Mairesse and Mohnen 2010). Nonetheless, innovation activities are not limited to the developed economies and are rather a widely globalized phenomenon (Demmel et al. 2017). In order for developing economies reach per capita income levels similar to richest economies', innovation and R&D are crucial and have become the main challenge for Latin America and the Caribbean countries (Crespi and Zuniga 2012). To clarify, R&D has been considered the primary source to foster the economic growth; and fostering innovation activities have become a pillar of public policies not only in developed economies, but also in several Latin America countries (Alcorta and Peres 1998; Aboal and Garda 2016; Mardones and Zapata 2019). Nevertheless, advanced and developing economies are divergent in their innovation and R&D profiles (Geldes et al. 2017). For instance, the determinants of investment in innovation activities in LAC are much more heterogeneous than in OECD countries as well as with the Asian New Industrializing Countries (NICs) (Arocena and Sutz 2000; Cassiolato and Lastres 2000; Crespi and Zuniga 2012; Santi and Santoreli 2017; Broome et al. 2018). Apart from this, Latin America and the

Caribbean countries have responded differently, adopting heterogeneous policy strategies as well as distinct growth trajectories to develop and sustain innovative activities (Castellacci and Natera 2016; Dutrénit et al. 2019).

Drawing from these issues, we follow Danese et al. (2018) developing a systematic literature review with several questions to shed light about innovation and R&D across manufacturing industries in Latin America and the Caribbean countries—*How is the innovation output scenario across Latin American industries? What kind of strategies Latin American and the Caribbean countries are adopting to improve their domestic innovation performance? What kind of public policies are implemented to foster the development of innovation? What kind of lessons we can learn after four decades of investments in innovation and R&D?* Considering these overarching questions, our study offers a novel and ambitious contribution to elaborate the first literature review in Latin America and the Caribbean countries to complement earlier literature in the field of innovation.

The contributions of our research are threefold. First of all, in particular, we begin with the concept described by the science philosophy of Ubaldi (1959), once it becomes fundamental the amalgamation between these two paths and the two forces. On his work—*The Great Synthesis*, the author specifically introduces a theory to explain the unitary phenomenology aspect of the formation of the Universe through a synthesis between philosophy and science. We follow the Ubaldi (1959) concept to understand the foundations of the most famous metaphorical phrase of Schumpeter (1942) to sought to explain how profound and critical is the innovation's cycle, a process present in all industries and human activities. We adopt this procedure, following Ceipek et al. (2019) idea, with an explanation and concepts behind the nature process of the innovation phenomenon.

Second, following (Danese et al. 2018; Calabrò et al. 2019; Ceipek et al. 2019; Vrontis and Christofi 2019) we draw a systematic literature review that allow us to review, understand and synthesize the representative literature. Accordingly, this method of research successfully and dramatically extended to other science fields (Danese et al. 2018; Ceipek et al. 2019; Vrontis and Christofi 2019), providing to the researchers the privilege of bringing more brightness. Specifically, such approach allows us to research a rich number of empirical cases, going further than the previous literature in Latin America—Brenes et al. (2016) with a special issue review and Olavarrieta and Villena (2014) and Rossetto et al. (2018) and Tello-Gamarra et al. (2018) with a literature review. In response, complementing and extending these previous studies, we propose a new approach with the systematic literature review to organize the extant knowledge—hereafter "state-of-the-art".

Third, innovation and R&D literatures has substantially dealt with developed economies, which has been extensively studied (Chudnovsky et al. 2006). We explore a large Region, with substantive challenges, but also with great opportunities. Such research is now mandatory, once when it comes to developing countries, such as LAC, the relationship between innovation and R&D is not as well established (Crespi and Zuniga 2012). For instance, in recent years Latin America innovative performance has lost significantly to Asian Tigers' economies and may soon fall behind China (Alcorta and Peres 1998; Moguillansky 2006). As such, we do not aim to study the evolution of innovation and R&D since the beginning, but importantly, we discuss the major issues to provide a deep and rich literature to share with other researchers.

Our systematic literature review begins motivated by the Schumpeter's innovation conceptualization as the starting point, with the amalgamation between philosophy and science, where we draw and clarify key definitions and conceptual matters in a phenomenology process to reveal how the innovation's process materializes in their essence. Next, we systematically describe the research procedures to unpack the literature with rigor and transparency. Then we continue systematically presenting our synthesis by topics to respond each of our four main questions, understanding the innovation and R&D across manufacturing industries in Latin America and the Caribbean countries. Finally, we appreciate some final insights and future remarks drawing the final conclusions and suggestions.

Definitions and concepts: innovation and R&D

While the concept of innovation may seem complex, perhaps, it can be simply straightforward to understand if we compare it to the human life. Everything that is born has to die, and that is through this process, that everything that had a beginning must end. A unitary process that always starts in birth and ends in death, syntropy and entropy, like a nebulous and a supernova, always with one beginning and a terminus—the life artifice (Ubaldi, 1959). This is the fundamental representation of a finite path, which always ends in destruction, as the metaphorical term of Schumpeter (1942). Notwithstanding, if we look carefully, we realize that actually, it's an infinite or eternal process, meaning the whole endeavor devoted, in some extent, is essential for the future generations. In other words, what exists remains and survives renewed by the destruction process. In this manner, we demonstrate that the same lesson can be applied to the innovation concept, once it is not an end per se (Chudnovsky et al. 2006).

We can highlight, perhaps, the most remarkable contribution of Schumpeter (1942, p. 83)—*Capitalism, Socialism, and Democracy*—regarding the modern industrial and capitalism

era. The author coined an evolutionary and famous concept, called—*the creative destruction*—becoming the key element in product and process innovations. To illustrate this eccentric phrase, we "break the ice" introducing the philosophy of science concept developed by the Italian Pietro de Alleori Ubaldi, Ubaldi (1959). While replicability of the authors' theory is not entirely possible, with acquiescence, we adapted it to our reflections. We follow the Ubaldi (1959) approach to understand the presuppositions embedded on the phenomenology process to take an additional meaning on the creative and dynamic full cycle of the master craftsman, from the *Promethean*[7] myth of Joseph Schumpeter, as it is illustrated by Fig. 1.

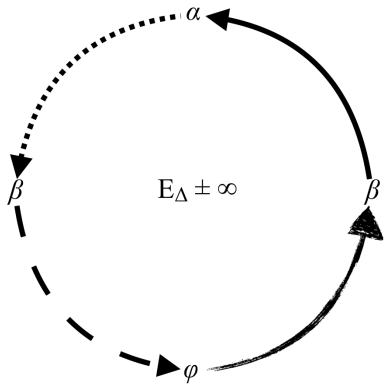

Fig. 1 Summary of the innovation concept. *Note*: Adapted from Ubaldi (1959, p. 60).

In a simply way the particular Fig. 1 can be translated by Eq. (1).

$$E_{\Delta} \pm \infty = \alpha \rightarrow \beta \rightarrow \varphi \rightarrow \beta \rightarrow \alpha$$

In order to understand the Fig. 1, we start with the term[8] $E_{\Delta} \pm \infty$ representing the given variation on the innovations across the time, a relative process. Where $\pm\infty$ is the infinite time

[7] Schumpeter's vision of creative destruction was faithful to the full cycle of the *Promethean* myth—no matter how high the mountain raised by the innovator, it is inevitably crumbling beneath his feet (Steinmueller 2010, p. 1202).

[8] Starting with $E_{\Delta} - \infty = \alpha$, where the innovation ends. This means that everything that has a beginning must have an end. If the destruction is indicated by $E_{\Delta} - \infty = \alpha \rightarrow \beta$, $E_{\Delta} - \infty$ represents the negative variation in one infinite space. Whatever has an end must have a beginning. The hardest part is the ending, which consists in starting to create again in a neutral space $E_{\Delta} \pm \infty = \varphi$. The creation means the beginning of the reverse process, where $E_{\Delta} + \infty$ represents the positive variation in one infinite space. The innovation emerges in one new mind concept φ which culminates in an intelligent phase, with new ideas and possibilities. The following process $E_{\Delta} + \infty = \varphi \rightarrow$

element, which means adding or subtracting a finite number to an infinity process leads to the infinity. In other words, an undetermined and incommensurable dimension that comprehend all the past behind (Ubaldi 1959). The term α represents the initial innovation stage, whilst β refers to two poles with opposed "magnetic fields" that permits to move the Schumpeterian "wheel of evolution". The origins of these two impulses moves in the anti-clockwise—from the process of destruction to the creation—where the left β sparks the innovation's destruction, whilst the right β gives their materialization. Yet, the past died and contains less; what interest is the future that contains more (Ubaldi 1959). The letter φ symbolizes the process of knowledge generation, an intelligent enough stage to originate either by the creation of something entirely new or their adaptation, resulting in the right β. We end this process returning to the beginning, with a new but transient α, in the middle of a giant and inevitably endless crumbling[9] innovation process. These two opposing movements give us profound reasons to consider the "*creative destruction*" metaphor on this conceptualization of innovation, where the new only could emerge after destroying their previous form.

As reflected, our clear and widespread innovation model is rooted in several innovation definitions across the literature, which means all innovations essentially needs to pass through the explained conceptualization. The literature defines innovation in several ways, as the conservatively words of Fagerberg et al. (2010, p. 835) innovation is defined as: "*one popular perception that innovation meets in media every day, is that it has to do with developing brand new, advanced solutions for sophisticated, well-off customers, through exploitation of the most recent advances in knowledge*". As such, innovation literature has substantially dealt with near concepts along our day-to-day life. Others offer a more encompassing perspective. Mansfield et al. (1971) defines technology as a critical piece of the innovation mechanics, as they wrote:

> Technology is society's pool of knowledge regarding the industrial arts and it is made up of knowledge used by industry, agriculture, government, and the professions concerning physical and social phenomena, knowledge concerning the application of basic principles and theories to work in these fields, and knowledge of the rules of

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β goes in the direction of the creation phase, materializing each new truly ideas and/or improving them. The end of the process results in a truly new innovation or an adaptation on the temporary innovation process $E_{\Delta} + \infty = \alpha$.

[9] The underlying vision of innovation, *Promethean* myth, indicates that the crumbling is an inevitable cycle based on the destruction of the innovation and inversion of poles in an endless innovation cycle over a gradual transformation.

> thumb and lore of craftsmen and practitioners regarding the day-to-day operations of production. (Mansfield et al. 1971, p. 2)

This is why technological advance is the result of a never-ending cycle of incoming innovative enterprises (Schumpeter 1934). Along similar lines, importantly, is a modern and recent definition; as the OECD (2018, p. 20) states: "*An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)".* Among many other definitions, on the Dosi et al. (1988. p. 222) words: "(…) *the search for, and the discovery, experimentation, development, imitation, and adoption of new products, new production processes and new organizational set-ups*". Apart from these, Schumpeter (1934) offers a set of definitions, specifying five types of innovation:

> "(…) innovation in a broad sense, as "carrying out of new combinations" that includes "the introduction of new goods (...), new methods of production (...), the opening of new markets (...), the conquest of new sources of supply (...) and the carrying out of a new organization of any industry" (Schumpeter 1934, p. 66).

As reflected, we agree with Joseph Schumpeter, and he argued correctly and activated an understanding over the innovation structure adopted for decades. These varying definitions encompasses new products, processes, raw materials, management methods, and markets and over time became one of the main driving forces underlying the micro- and macro-economic growth (Scherer 2005). As well-explained above, there are an uncountable variety of innovation concepts and definitions (Geldes et al. 2017), that results in only one word—innovation.

Given those definitions, and considering that innovation is a multidimensional process, it is necessary to understand what conducts and fosters the process of innovations in all economies. The fundamental engine to develop and sustain innovations relies on Research and Development activities (Kafouros 2008, p. 20), which also creates scientific knowledge (Griliches 1979). Nevertheless, we explain that R&D is not merely an engine, but also constitutes the fuel that moves a sophisticated mechanical artifact to produce "innovations". It is similar to the *Hydrogen* (*H*) and *Helium* (*He*), the simplest members of the family of chemical elements, and the fuels to the sun' light. In modern times, we explain in a simple way, that R&D is not merely an engine, but one of the fuels that brings luminescence and wealth to all human activities.

As far as we know, R&D plays a fundamental role in innovations to develop new competencies and skills, necessary to seek, acquire, and adapt the existing technology

(Benavente et al. 1997; Chudnovisky et al. 2006; Kafouros 2008; Mardones and Zapata, 2018). These varying presented definitions reflects that all technological progress is the heart of development (Goedhuys and Veugelers 2012). Besides that, the innovation and R&D becomes valuable as firms develop technological skills and internal knowledge, an essential to spur economic growth, caching-up and raising living standards (Crespi and Zuniga 2012).

Method

We followed the previous methodology described by (Danese et al. 2018; Calabrò et al. 2019; Ceipek et al. 2019; Maia et al. 2019; Vrontis and Christofi 2019) with the sufficient and necessary ground to answer the research objective and focus on a deep systematic literature review of the state-of-the-art in innovation and R&D in manufacturing industries across Latin American and the Caribbean countries that will bring clear and precise insights to our questions. The systematic literature review offers numerous advantages compared with the unstructured reviews (e.g., Olavarrieta and Villena 2014; Brenes et al. 2016) and the traditional bibliometrics studies (e.g., Rossetto et al. 2018; Maia et al. 2019) once permit us to adopt a quality literature analysis (Danese et al. 2018; Ceipek et al. 2019). Thus, the systematic literature review allows our study to offer significant contributions in the field of analysis (Danese et al. 2018).

Questions formulation and criteria

We followed (Calabrò et al. 2019; Vrontis and Christofi, 2019) research frameworks, as a starting point to an appropriate blueprint criterion and to delimitate the conceptual research boundaries. We conducted an informal search to identify the most suitable scientific electronic bases. At next, we decided to choose three formal specific electronic scientific bases in the fields of interest—business, economics and management—to attain a detailed review called state-of-the-art. The first electronic base is *Thomson Reuters ISI—Web of Science* (*Principal Collection*) providing a wide range of journals. The second is *Scopus* (*Elsevier B.V.*), followed by the third, the publisher *Taylor & Francis Group*. The decision to choose them consists in choosing the most common and comprehensive databases with the most rated articles. Additionally, *Scopus* (*Elsevier B.V.*) and *Taylor & Francis Group* comprehend a large coverage number of articles working with Latin America and the Caribbean countries.

An important step was to identify all the relevant literature keywords. We developed our search iteratively into small keyword groups using truncation in the search strings to

identify all relevant studies including their variants (Calabrò et al. 2019; Vrontis and Christofi 2019). To inform the keywords we relied on systematic literature works (see, Calabrò et al. 2019; Vrontis and Christofi 2019) and, also, considered the traditional literature with interest in innovation and R&D. Each keywords group were associated with the Boolean "OR" operator to generate a search string for the respective group and the "AND" operator to combine search strings.

The first group entails the term—*innovat*—with asterisks [innovat*]. This procedure allows us to scan every variation in the innovation roots word (e.g., innovation, innovative, innovativeness, innovatively). The second group of words are—"R&D", "Research and Development" and "Research & Development"—which allow us to capture all R&D word variants. For all this group of words [topic = innovat* OR "R&D" OR "Research and Development" OR "Research & Development"] we decided to use "Topic" in the search, once it scans over all the researches titles, abstracts and keywords. Nonetheless, only in the *Scopus Elsevier B.V* database it was necessary to use the "title" instead of "topic" in the search field, because the literature is so vast and the scientific electronic base have a limitation to export the data over 2000 studies. The last group is represented by the Boolean "AND" with (Latin*). Adopting the (*) on Latin word (Latin*), allowing us to capture any related Latin country mentioned across the text' articles. A summary of the full syntax, method and criteria is detailed in the notes of the Fig. 2.

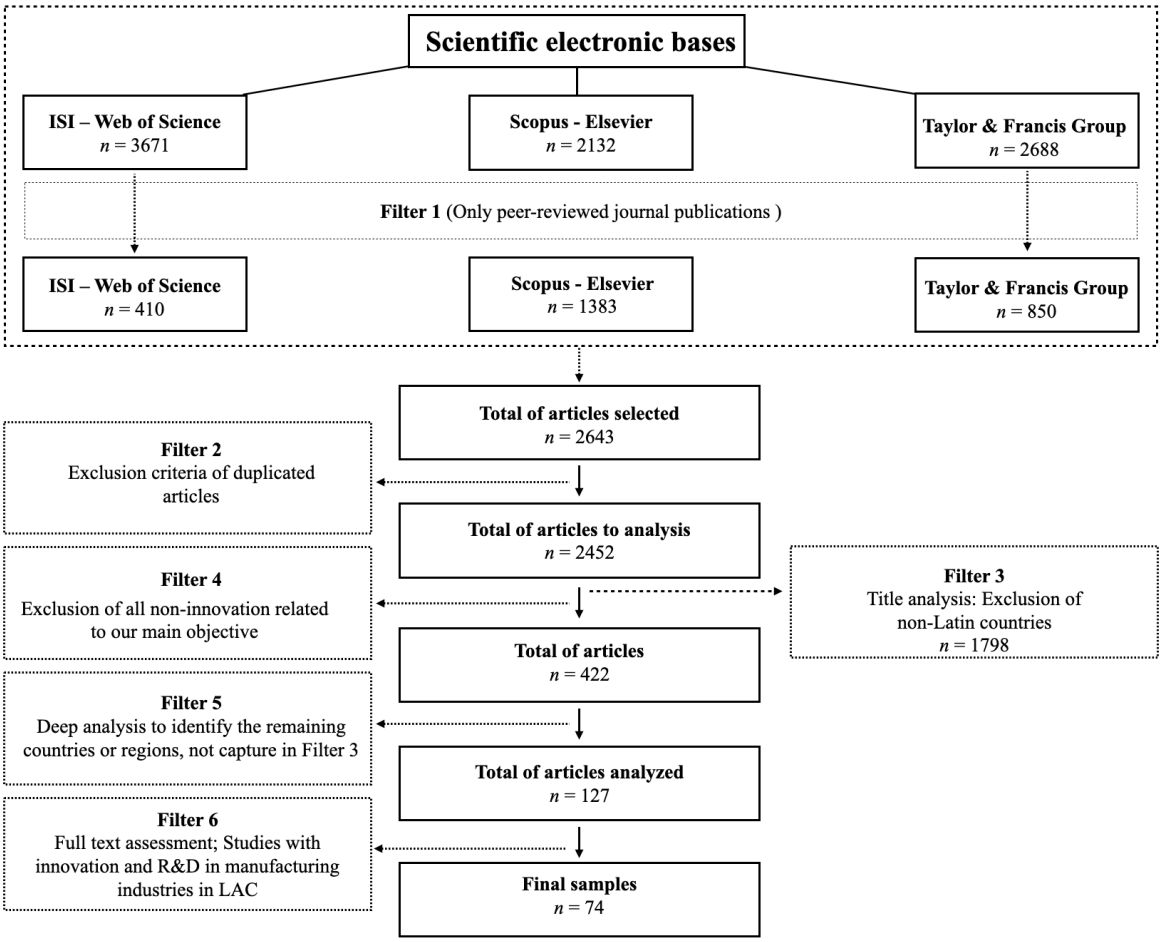

Fig. 2 Mapping the search of innovation and R&D in Latin America manufacturing industry. *Notes*: Search criteria for *Web of Science*: Date: January 1945–May 2020, Search strings: [(Innovat* OR "R&D" OR "Research and Development" OR "Research & Development") in topic "AND" (Latin*) in all fields], only articles in economics or management or business, only research articles, (language: only English). *Scopus—Elsevier B.V*: Date: Since the beginning–May 2020, Search strings: [(Innovat* OR "R&D" OR "Research and Development" OR "Research & Development") in title "AND" (Latin*) in all fields], only articles in business and economics or management, only research articles, (language: only English). *Taylor & Francis Group*: Date: Since the beginning–May 2020, Search strings: [(Innovat* OR "R&D" OR "Research and Development" OR "Research & Development") in topic (base restriction) "AND" (Latin*) in all fields], only research articles in economics, finance, business & industry (languages: is not restricted).

Inclusion and exclusion criteria

In what follows we examine the contours of the criteria informed above. This initial search generated a long sample list of 8491 articles. After that, we separated all these articles in two categories. The first one is the raw data, Fig. 2. The second (see, Filter 1) is restricted to peer-reviewed scholarly journal (Calabrò et al. 2019; Vrontis and Christofi 2019), excluding books, book chapters and other non-refereed publications (editorials, conference papers and extended abstracts). Moreover, we adopted only articles in the field of economics, management and business and only research articles with the English language. After these procedures, the sample was reduced to 2643.

Search for relevant researches

After the above procedure, we adopted the exclusion criteria of duplicated researches (Danese et al. 2018; Calabrò et al. 2019; Vrontis and Christofi 2019) resulting in 2452 articles (see, Filter 2). After cleaning the duplicates (see, Filter 3) the sample was reduced to 1798 articles, mainly by evaluating the articles' titles. For instance, at this stage (see, Filter 3) we removed all articles visible by their titles that were not related to Latin countries (e.g., China, Korea, Taiwan, Japan, United States, United Kingdom, Germany and, other European countries as well as Africa and all other non-Latin countries). With a broad range of documents we followed then a hand search to analyze all the titles and abstracts (see, Filter 4) in search to exclude all types of innovation that are not related to our main objective (e.g., family business innovation, energy, sustainable, low-carbon, natural resources, health, medical, entrepreneurial and management, business model innovation, banking, agribusiness, farm, rural, bio-technology, marketing innovation, logistics, global value chain, supply-chain and service innovation, hotel, tourism, university, social governance, accountability, open-innovation, educational, e-commerce, gender and so on). We removed such studies from our review once they did not correspond directly to our objective, so they might result in other future literature researches. A total of 422 studies were separated to the final step.

The final step considers a full text assessment, with a deep analysis to identify what countries or regions these researchers are working (see, Filter 5). This process captures the countries that were not possible to be identified on the titles (Filter 3). For instance, the country' or region' information is only highlighted in the articles' methodology. We tight more this stage (see, Filter 6), reading the full text with the following keywords and topics—innovation and

R&D and Latin countries in the same research—at firm-level (micro-economic) or country-level (macroeconomic). After a carefully hand search and full text analysis, we selected only articles in innovation and R&D in manufacturing industries, also the focus of this empirical work. A total of 127 studies were identified.

As scholars, to ensure the quality of the sample, we limited ourselves to peer-reviewed journal publications with the *Herfindahl-Hirschman Index (h-index)* provided by *SCImago Lab—SCImago Journal & Country Rank—SJR*. The *SCImago Journal & Country Rank* is a publicly available portal that includes the journals and country scientific indicators developed from the information contained in the *Scopus* database—Elsevier B.V. (SJR 2020). The literature has adopted the *SJR* for innumerous reasons due the number of information's provided. *SJR* provides detailed analysis of the citation origin and citation behavior of each research area, country and publisher. For instance, Maia et al. (2019) adopted the *SJR* to consider the quality country analysis. In our research we did different, we adopted the *SJR* to stablish the quality citation limit with a minimum of 20 points *h.index*. As a result of these steps, 74 publications makes the sample to our systematic literature review.

Descriptive analysis

This section analyses the collected data. Table 1 reports the main outcomes obtained from the analysis related to the selection of 74 references by analyzed country, methodology, ISSN and by higher *SJR h.index* (May-2020).

It is possible to observe that there is a large number of researches in innovation and R&D in Latin America and Caribbean mainly published in high quality journals, Table 2. Most references came from the highest *h-index* journals, such as *Research Policy* (*n*=7/*h*=224), followed by *Journal of Business Research* (*n*=4/*h*=179) and *World Development* (*n*=5/*h*=164). Considering the *h.index*, the majority of international peer- reviewed journals are in the fields of *Business and Economics*, which covers a large number of empirical researches aiming developed and developing economies.

Table 1 Articles included in the sample organized by *Scimago Journal & Country Rank—SJR*

# Reference	Analyzed country	Method / Model	ISSN (on-line)	*h. index*
1 Chudnovsky et al. (2006)	Argentina	Empirical / CDM	0048-7333	206
2 Alcorta and Peres (1998)	Multiple	Empirical	0048-7333	206
3 Crespi et al. (2016)	Argentina	Empirical OLS/GMM	0048-7333	206
4 Padilla-Pérez and Gaudin (2014)	Central America	Empirical	0048-7333	206
5 Frank et al. (2016)	Brazil	Empirical / CDM	0048-7333	206
6 Paunov (2012)	Multiple	Empirical / Probit	0048-7333	206
7 Katz (2001)	Multiple	Empirical	0048-7333	206
8 Pino et al. (2016)	Multiple	Empirical EFA/CFA	0148-2963	179
9 Brenes et al. (2016)	Multiple	Review / *Special Issue*	0148-2963	179
10 Santos et al. (2014)	Brazil	Empirical	0148-2963	179
11 Olavarrieta and Villena (2014)	Multiple	Review / *Special Issue*	0148-2963	179
12 Crespi et al. (2020)	Chile	Empirical / TFP	0305-750X	164
13 Busom and Vélez-Ospina (2017)	Colombia	Empirical / CDM	0305-750X	164
14 Castellacci (2015)	Multiple	Empirical	0305-750X	164
15 Crespi and Zuniga (2012)	Multiple	Empirical / CDM	0305-750X	164
16 Katz (2000)	Multiple	Literature Review	0305-750X	164
17 Fernandes and Paunov (2015)	Chile	Empirical /Logit/OLS	1530-9142	153
18 Katz (1984)	Multiple	Empirical	0304-3878	133
19 Geldes et al. (2017)	Chile	Empirical / Logit	0019-8501	125
20 Pérez et al. (2019)	Multiple	Empirical / SSIs	0166-4972	121
21 Milesi et al. (2013)	Argentina	Empirical	0166-4972	121
22 Santi and Santoleri (2017)	Chile	Empirical / OLS/PSM	1573-0913	120
23 Castillo et al. (2014)	Argentina	Empirical	1573-0913	120
24 Crespi et al. (2019)	Multiple	Empirical / CDM	1464-3650	104
25 Aboal and Tacsir (2018)	Uruguay	Empirical	1464-3650	104
26 Cimoli and Katz (2003)	Multiple	Empirical	1464-3650	104
27 Dutrénit et al. (2019)	Multiple	Empirical	0040-1625	103

Table 1 (continued)

# Reference	Analyzed country	Method / Model	ISSN (on-line)	*h. index*
28 Pérez et al. (2018)	Multiple	Empirical / PSM	0040-1625	103
29 Yigitcanlar et al. (2018)	Brazil	Empirical	1467-9310	99
30 Oura et al. (2016)	Brazil	Empirical / SSIs	0969-5931	87
31 Broome et al. (2018)	Caribbean	Empirical/Tobit/ Probit	1464-5114	83
32 Mohan et al. (2018)	Caribbean	Empirical	1464-5114	83
33 Dobrzanski (2020)	Multiple	Empirical / DEA	1466-4283	78
34 Taveira et al. (2019)	Brazil	Empirical / CDM	1466-4283	78
35 Fleury et al. (2013)	Brazil	Empirical / Mixed	1075-4253	66
36 Guimón et al. (2018)	Chile	Empirical / SSIs	1075-4253	66
37 Gómez-Valenzuela et al. (2020)	Dominican Rep.	Empirical / CA	1465-3990	64
38 Fernandéz-Sastre and Reyes-Vintimilla (2020)	Ecuador	Empirical	1465-3990	64
39 González-Álvarez and Argothy (2019)	Ecuador	Empirical / OLS	1469-8390	57
40 Kesidou and Snijders (2012)	Uruguay	Empirical	1469-8390	57
41 Cassiolato and Lastres (2000)	Multiple	Empirical	1469-8390	57
42 Arocena and Sutz (2000)	Multiple	Qualitative	1469-8390	57
43 Petelski et al. (2020)	Argentina	Empirical / PSM	1476-8364	49
44 Berrutti and Bianchi (2020)	Uruguay	Empirical	1476-8364	49
45 Ramírez et al. (2019)	Colombia	Empirical / CDM	1476-8364	49
46 Muinelo-Gallo and Martínez (2018)	Uruguay	Empirical / CDM	1476-8364	49
47 Santiago et al. (2017)	Mexico	Empirical / MPM	1476-8364	49
48 Fernandez (2017)	Multiple	Empirical / Latent	1476-8364	49
49 Aboal and Garda (2016)	Uruguay	Empirical / CDM	1476-8364	49
50 Benavente (2006)	Chile	Empirical / CDM	1476-8364	49
51 Demmel et al. (2017)	Multiple	Empirical / Probit	1467-9361	47
52 Tello (2015)	Peru	Empirical / CDM	1467-9361	47
53 Benavente et al. (1997)	Multiple	Empirical / Mixed	1469-9966	46
54 Castellacci and Natera (2016)	Multiple	Empirical	0954-349X	45

Table 1 (continued)

# Reference	Analyzed country	Method / Model	ISSN (on-line)	*h. index*
55 Zuniga and Crespi (2013)	Multiple	Empirical	0954-349X	45
56 Goedhuys and Veugelers (2012)	Brazil	Empirical / Probit	0954-349X	45
57 Mardones and Zapata (2019)	Chile	Empirical / CDM	1476-8364	44
58 Hall and Maffioli (2008)	Multiple	Empirical	1743-9728	44
59 Raffo et al. (2008)	Multiple	Empirical / CDM	1743-9728	44
60 Moguillansky (2006)	Multiple	Literature review	1946-326X	44
61 Pombo (2001)	Colombia	Empirical / TFP	1465-3486	37
62 Aboal et al. (2015)	Uruguay	Empirical / OLS / IV	1558-0938	29
63 Crespi et al. (2015)	Colombia	Empirical	1558-0938	29
64 Gallego et al. (2015)	Colombia	Empirical / CDM	1558-0938	29
65 Bravo-Ortega et al. (2014)	Chile	Empirical / ALS	1558-0938	29
66 Elejalde et al. (2015)	Argentina	Empirical /	1558-0938	29
67 Fernández and Gavilanes (2016)	Ecuador	Empirical / OLS	1469-9559	28
68 Dutrénit and Katz (2005)	Multiple	Empirical	1447-9338	27
69 Cuervo-Cazurra et al. (2019)	Multiple	Qualitative	1525-383X	26
70 Tello-Gamarra et al. (2018)	Multiple	Literature review	0718-2724	25
71 Mardones and Zapata (2018)	Chile	Empirical /	0718-2724	25
72 Gómez-Valenzuela (2015)	Dominican Rep.	Empirical /CA	0718-2724	25
73 Brown and Gúzman (2014)	Mexico	Empirical / CDM	0718-2724	25
74 Avila-Lopez et al. (2019)	Multiple	Empirical / Granger	1667-6726	20

Notes: (1) CDM = Crépon, Duguet and Mairesse model; (2) PSM = Propensity Score Matching; (3) SSIs = Semi-Structured Interviews; (4) OLS = Ordinary Least Squares; (5) TFP = Total Factor Productivity; (6) ALS = Asymptotic Least Squares; (7) SFA = Stochastic Frontier Analysis. (8) CA = Conjoint Analysis; (9) SQ = Structural equation; (10) DEA = Data Envelopment Analysis; (11) GMM = Generalized Method of Moments; (12) EFA = Exploratory Factor Analysis; (13) CFA = Confirmatory Factor Analysis; (14) Granger = Granger causality; (15) Latent = Latent Regression; (16) MPM = Multivariate Probit Model; (17) IV = instrumental variables; (18) Mixed = qualitative and quantitative data.

Table 2 Academic journals outlets organized by *Scimago Journal & Country Rank—SJR*

# Journal	N. of papers	Journal country	ISSN (on-line)	Publisher	*h. index*
1 Research Policy	7	NL	0048-7333	Elsevier	224
2 Journal of Business Research	4	NL	0148-2963	Elsevier	179
3 World Development	5	UK	0305-750X	Elsevier	164
4 Review of Economics and Statistics	1	US	1530-9142	MIT Press	153
5 Journal of Development Economics	1	NL	0304-3878	Elsevier	133
6 Industrial Marketing Management	1	NL	0019-8501	Elsevier	125
7 Technovation	2	UK	0166-4972	Elsevier	121
8 Small Business Economics	2	NL	1573-0913	Springer	120
9 Industrial and Corporate Change	3	UK	1464-3650	Oxford	104
10 Technological Forecasting and Social Change	2	NL	0040-1625	Elsevier	103
11 R&D Management	1	UK	1467-9310	Blackwell	99
12 International Business Review	1	UK	0969-5931	Elsevier	87
13 Entrepreneurship and Regional Development	2	UK	1464-5114	Routledge	83
14 Applied Economics	2	UK	1466-4283	T&F	78
15 Journal of International Management	2	US	1075-4253	Elsevier	66
16 Technology Analysis and Strategic Management	2	UK	1465-3990	Routledge	64
17 Industry and Innovation	4	UK	1469-8390	T&F	57
18 International Review of Financial Analysis	1	NL	1057-5219	Elsevier	49
19 Economics of Innovation and New Technology	8	UK	1476-8364	T&F	49
20 Review of Development Economics	2	UK	1467-9361	Blackwell	47
21 Oxford Development Studies	1	UK	1469-9966	T&F	46
22 Structural Change and Economic Dynamics	3	NL	0954-349X	Elsevier	45
23 Journal of Economic Issues	1	UK	1946-326X	T&F	44
24 The European Journal of Development Research	2	UK	1743-9728	Palgrave	44
25 International Review of Applied Economics	1	UK	1465-3486	T&F	37

Table 2 (continued)

# Journal	N. of papers	Journal country	ISSN (on-line)	Publisher	*h. index*
26 Innovation: Management, Policy and Practice	1	UK	1447-9338[1]	T&F	29
27 Emerging Markets Finance and Trade	5	US	1558-0938	T&F	29
28 Journal of International Trade & Economic Development	1	UK	1469-9559	Routledge	28
29 Multinational Business Review	1	UK	1525-383X	Emerald[2]	26
30 Technology Management and Innovation JOTMI	4	CN	0718-2724	JOTMI	25
31 Journal of Applied Economics	1	UK	1667-6726	T&F	20

Note: [1] = PRINT ISSN (changed to Innovation: Organization & Management); [2] Emerald Group Publishing Ltd.; (1) T&F = Taylor & Francis Group; (2) NL = Netherlands; UK = United Kingdom; US = United States; CN = Chile; (3) Blackwell = Wiley-Blackwell; (4) Palgrave = Palgrave Macmillan; (5) Oxford = University Press.

Furthermore, in general, articles focus mainly on quantitative approach with greater emphasis on empirical works across the decades. Primarily, authors adopted the CDM—Crépon et al. (1998) model—as an econometric approach (we explain this in more detail in the "Literature analysis"). We anticipate that there is a methodology' gap, once there is a lack of studies adopting other empirical approaches. As described in Table 2, we observed a concentration of Latin American researches in the *Economics of Innovation and New Technology* (*n*=9/*h*=49) and *Emerging Markets Finance and Trade* (*n*=5/*h*=29) journals.

In order to capture the proportion of the analyzed researches in the scientific electronic bases, Fig. 3 represents the number of articles focusing on innovation and R&D in Latin American and Caribbean countries. One interesting result is the large single base containing a large number of articles *Scopus* (*n*=21/28%), followed by *Taylor & Francis Group* (*n*=8/11%) and *ISI—Web of Science* (*n*=7/9%). Details of the data reveals that articles using both databases *ISI—Web of Science/Scopus* represents (*n*=17/23%). Furthermore, *Scopus/Taylor & Francis Group* indicates (*n*=14/19%). Nonetheless, we found only 1 article present in the base *ISI—Web of Science* and *Taylor & Francis Group* (*n*=1/1%). Finally, articles in the three bases *ISI—Web of Science/Scopus/Taylor and Francis Group* indicating (*n*=6/8%). This information is notably relevant to future research into the field of innovation and R&D in LAC.

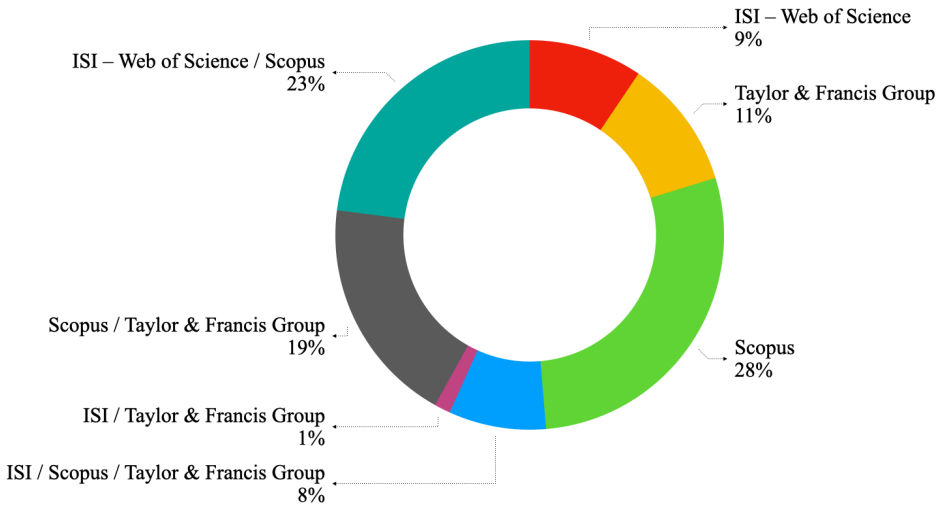

Fig. 3 Articles distribution by electronic base focusing on innovation and R&D

In terms of geographic coverage, Fig. 4, this analysis becomes crucial, once it enables us to observe the research evolution of the field of innovation and R&D across the Latin countries. We found a predominant number of works with multiple countries (*n*=30/40,54%). Nevertheless, in general, the studies focused on multiple countries considers the micro data

from industrial surveys. Here, we identified two gaps. The first is the lower number of single-country-based studies considering medium and small size economies. The second is a lack of heterogeneity countries. In short, there is a necessity to investigate the impact of innovation and R&D investments over small Latin economies (e.g., Peru, Bolivia, Venezuela, Paraguay, Guyane Française/Guyane) and, specifically on the Caribbean and the small and open economies from Central America—Panama, Costa Rica, Nicaragua, Honduras, El Salvador, Guatemala, and Belize (Broome et al. 2018; Mohan et al. 2018) to enrich the Latin American literature.

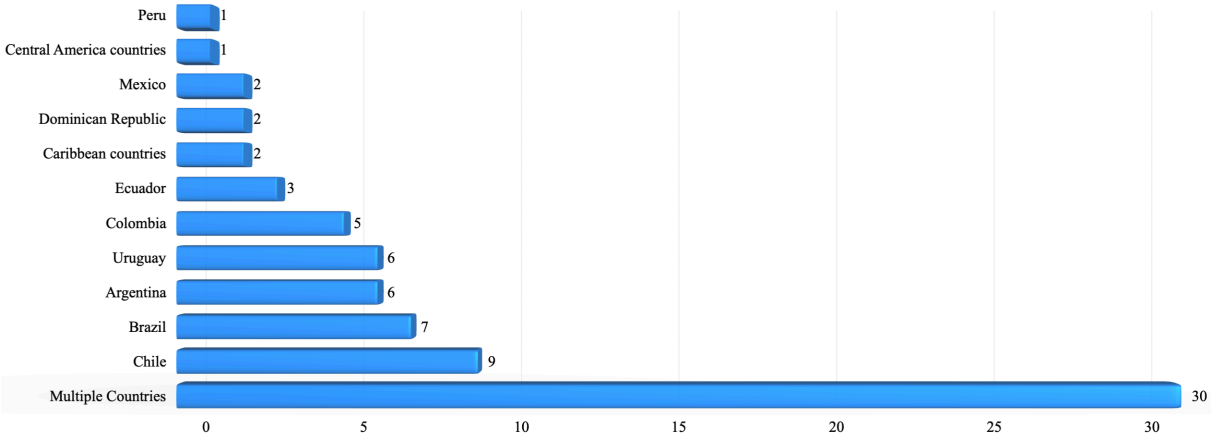

Fig. 4 Number of target countries analyzed in each paper

Our search also identified studies that considered the innovation and R&D or explored patterns of technological antecedents across manufacturing industries in Latin America and the Caribbean countries, Fig. 5. By these means, we open the discussion to understand the innovation and R&D patterns decades ago (1984 and 1997). After 2000-year innovation and R&D gained more attention in developing economies, such as China and India, and started to emerge in Latin American countries. In line with Tello-Gamarra et al. (2018) we identified that, before 2006, not many papers were published in Latin America, although this did not mean that the LAC do not invest in innovation and R&D.

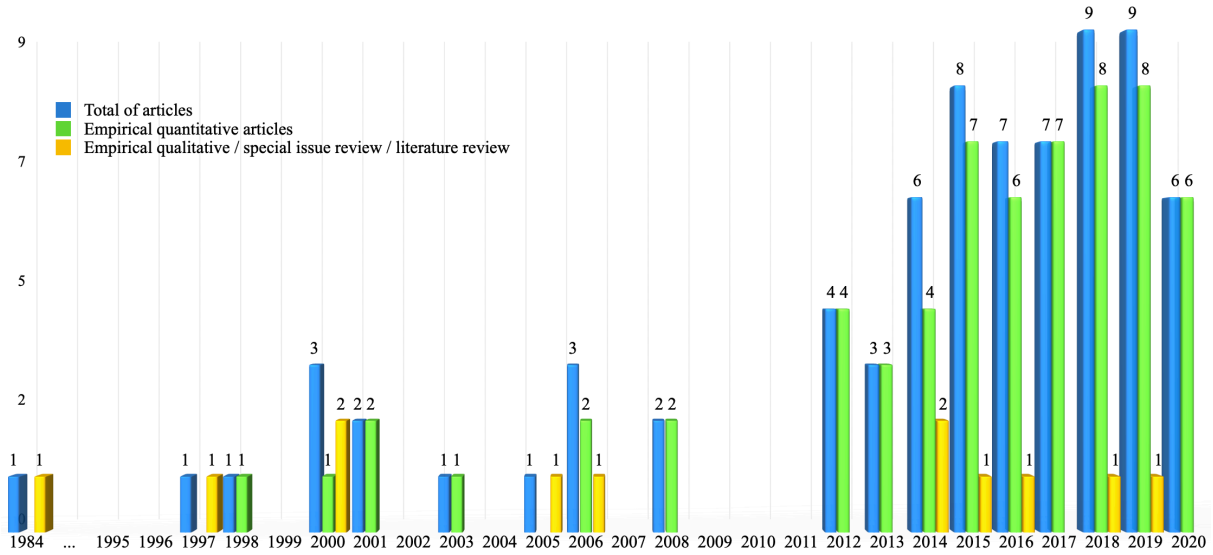

Fig. 5 Articles frequency by year (from 1984 to may-2020).

Almost four decades later from the first work, it is possible to observe an initial growth in academic research related to Latin countries after 2006, where the number of empirical quantitative researches started to emerge (*n*=64 articles/86,49%). A methodology' gap is observed once there is a lack of studies adopting qualitative investigations. As such, the literature argued that a qualitative approach is an important methodology to capture results not observed in quantitative researches.

Latin America and the Caribbean innovation and R&D: an overview

The origin of our research questions relies in Katz (1984) and Benavente et al. (1997), opening the discussion with a detailed story about the issues and opportunities for industrial development in Latin America. The author debates about the Latin industry background between 1970 and 1994. Historically, over the past 50 years, great changes have taken place in Latin America innovation politics, since 1970, when the mass production system in developed countries reached maturity (Moguillansky 2006). This period was often referred as "market reform era" (Dutrénit and Katz 2005; Castellacci and Natera 2016) and endured along 1980–1990 with structural reform programs implemented under the inspiration of the *Washington Consensus*, aiming the trade and financial liberalization, privatization, and neutrality in policy intervention (Alcorta and Peres 1998; Hall and Maffioli 2008; Padilla-Pérez and Gaudin, 2014). Furthermore, Foreign Direct Investment (FDI) increased quite significantly in Latin-American during the 1990s with the globalization of the world economy (Dutrénit and Katz 2005). More specifically, during 1980–1990, the number of R&D scientists and personnel engaged in R&D

increased by 87.5%, the highest number of R&D scientists and engineers per million population in the developing world region (Alcorta and Peres 1998), this also happened due to the dynamic integration between countries during the 1990s (Pombo 2001).

Significant economic changes have taken place in Latin America and Caribbean between the "lost decade" of the 1980s (financial debit crisis) and the recovery on the 1990s, when the region became increasingly integrated to the globalization process (Moguillansky 2006). For instance, the background, set in import substituting industrialization (1935–1970) has given way to a transition towards a new productive structure and new methods of organization of manufacturing activity. The reforms have acted as major "selection mechanisms" favoring certain types of firms, industries and regions, and triggering off a significant process of business and wealth concentration with major, but unknown long-term consequences (Benavente et al. 1997). For instance, Moguillansky (2006) argued the globalization process and the economic reforms were responsible to benefit preferentially transnational enterprises, which became leading actors in the capital formation process in the region. In contrast, the authors pointed out that the growth strategy of the enterprises did not incorporate adequately—except for some few exceptions—local suppliers or strengthen the Nation Innovation Systems (NIS).

In such an environment, the strong link between innovation and institutions was highlighted by Alcorta and Peres (1998) analyzing the Nation Innovation Systems after the 1950s. Cassiolato and Lastres (2000) explain that the public sector played the most important role in the development of national innovation systems. In some countries (e.g., Brazil, Costa Rica and Venezuela), this led to the creation of Ministries of Science and Technology, while in others, the policy-making authority was assigned to special divisions within other ministries (Hall and Maffioli 2008). The authors measured the innovative performance of LAC focusing on the technological content trade flows by the composition of high-tech exports over the total exports. As far as relative labor productivity is concerned, it seems that not much has yet happened in terms of closing the gap with the world's best practice standards (Benavente et al. 1997) and in general, one of the main characteristics of LAC's system of innovation consists in very low level of aggregate expenditure in R&D (Alcorta and Peres 1998; Broome et al. 2018). For instance, the expenditure per capita in LAC was much lower than other non-African developing countries and only 12% higher than that of African countries in 1992 (Alcorta and Peres 1998). Additionally, during this period most R&D activities were performed by state-owned enterprises (SOEs) labs and technology institutes, public universities and R&D departments of state enterprises (Cassiolato and Lastres 2000).

A key study examined a more recent period (1970–1996). Katz (2000) analyzed the pattern of production specialization by Latin manufacturing industries in parallel to the macro and micro forces trying to close the gap with the international technology frontier. The author argued that the structural reform in LAC did not result in a major discontinuity with the past, especially with the import substitution idea (period of 1935 parallel 1970). The conclusion goes in the same line of Alcorta and Peres (1998), considering that Latin American countries have a poor innovative performance, nonetheless, with improvement in productivity growth but with large gap compared to United States. For instance, although, whereas developed and some developing countries were strengthened by the virtuous circle of innovation, capital accumulation, and growth, this region has been affected in the opposite manner (Moguillansky 2006). Accordingly, there is a lack of interaction between government support and organization, investments in intangible and human capital, as public policies, resulting in low productivity and weak innovative performance compared to more developed economies and Asian Tigers' (Alcorta and Peres 1998; Moguillansky 2006).

Literature analysis

In this section, we review the past and present literature in small topics, and subsequently we specifically answer each research question based on the innovation and R&D findings.

Product and process innovations and R&D

From an economic, business and managerial perspective, innovation is crucial for firms, also one of the main determinants of economic growth (Dobrzanski 2020). On these roots, the primary contribution came from Chudnovsky et al. (2006) analyzing the magnitude and diffusion of innovation activities in Argentina. The author opened an interesting path of investigation based on the Crépon et al. (1998)—hereafter CDM approach (the authors initials). The model is a more refined perspective of the knowledge production function (with R&D), since the work of Griliches (1979). A key feature of this approach is related to the adoption of the three-stages and four structured equations, where R&D, innovation and productivity are estimated in a recursive sequential way (Raffo et al. 2008). Recent studies have focused on the CDM lenses using firm's micro data from industrial survey following the Community Innovation Survey—CIS guidelines. Over the years, researchers adopted this perspective in several scientific fields, topics to solve problems in different countries. Moreover, this approach

has critical empirical attractiveness to accommodate the issues of selectivity and endogeneity, in estimating the relationship between R&D, innovation and productivity (Crespi and Zuniga 2012; Taveira et al. 2019).

The research of Chudnovsky et al. (2006) and Benavente (2006) shed light on the impact of different innovation activities on the innovation outputs (product and process innovation) and productivity, in Argentina and Chile, respectively. As denoted by Fleury et al. (2013 p. 267) there are the two main types of innovation in the literature. Firstly, product innovation was considered core if the company prioritized new product activity and consequently introduced new products into the market. Secondly, process innovations were considered core if the company introduced new or significantly improved production technologies, methods for providing services or for the handling and delivery of new or substantially improved products. In this way, Chudnovsky et al. (2006) points out that in- house R&D and technology acquisition expenditures enhances the probability of product and/or process innovations, which in turn attains higher productivity levels than non-innovators. At this point, it is recommended that firms need to consider R&D activities as part of their routines, even in the bad times—crisis (Paunov 2012), once discontinuing in-house R&D activities may cause negative influence on innovation outputs. For instance, engaging in product innovation reduces Chilean plants' exit probabilities and also the firm plant death (Fernandes and Paunov 2015).

Several Latin researches were motivated by the CDM approach (Crepón et al. 1998; Benavente 2006; Chudnovsk et al. 2006). To complement these past researches, later study focused on the total of innovation investment rather than R&D expenditures as a dependent variable (Crespi and Zuniga 2012). In this respect, more recent research emphasizes the importance to pay attention to other innovation activities beyond R&D (Crespi et al. 2016; Aboal and Tacsir 2018). Specifically, Crespi and Zuniga (2012) pointed out that there is an evidence of the importance of knowledge for innovation and a very strong association between innovation and productivity. Overall, introducing technological innovation is associated with increases of about 100% in labor productivity. In other words, this is one of the reasons why is highly recommended that firms continue to invest in R&D activities, even if on small scale (Chudnovsky et al. 2006). Recently, in a study with many firms, Demmel et al. (2017) investigated the innovation link between two types of innovation (product and process) and the productivity for manufacturing firms in four Latin American countries. They were classified as upper-middle income country—Argentina and Mexico—and lower middle income—Colombia and Peru. The level of development in innovation and productivity are both related to product

and process innovation to middle income countries—Argentina and Mexico (Demmel et al. 2017).

There is, however, limited empirical work investigating innovations and R&D investments on state-owned-enterprises (SOEs). It is well known that public and private firms invest in R&D in order to grow, ultimately survive and in the same way to foster the survivability, growth and sales (González-Álvarez and Argothy 2019). Building on these points, there is also a lack of focus on researches exploring the relationship between R&D and innovation with consortium with SOEs. In this respect, such activity is a common activity in emerging economies, such as China. Importantly too, SOEs seems to be an essential engine for improving national and international positions (González-Álvarez and Argothy 2019).

Innovation and R&D outputs on EMNEs

Emerging market multinational enterprises (EMNEs) are becoming increasingly credible and vigorous competitors against advanced economy (Cuervo-Cazurra et al. 2019). By this means, several Latin American companies are climbing the value chain by deploying new strategies in traditional industries (Brenes et al. 2016). For instance, in the case of the Brazilian multinationals, these firms are expanding in traditional sectors of the global economy, and not necessarily in those regarded as knowledge-intensive (Fleury et al. 2013). For example, in Brazil, Frank et al. (2016) suggests that strategies to innovate implies in investing in market-oriented innovation, in activities such as, internal and external R&D, commercialization and new product development. Specifically, in terms of the intensity of innovation expenditure, EMNEs have a significantly higher level of investment—Argentina, Colombia, and Panama (Crespi and Zuniga 2012). Nonetheless, Crespi et al. (2014) explain that there is a special group of world-class MNEs that invest in R&D, regarding biotechnology and agribusiness sector (Cassiolato and Lastres 2000).

In general, when it comes to innovations, the literature criticizes the LAC context, because Latin America is moved by non-technological or basic commodities activities. For instance, in the case of emerging markets there are some limitations to innovate that differ from developed markets (Geldes et al. 2017). Surpassed this condition, different from product and process innovations—commodity innovations exist (Fleury et al. 2013). In this regard, EMNEs are developing the so called “uncommoditizing” strategies (Cuervo-Cazurra et al. 2019). They explain that, one of them are the tropicalized innovations—whereby firms develop innovations and brands adapted to the unique needs of emerging economies and to gain customer

preferences. Finally, it is important to mention that, most of EMNEs does not show highly innovative products, whereas these firms developed important organizational (Frank et al. 2016; Pino et al. 2016) and administrative competences combined with product innovation to venture abroad in the international markets (Fleury et al. 2013).

Innovation and R&D in large and small and medium enterprises

Importantly too, is the context of the innovation performance and R&D investments by SMEs. Researchers clearly identified the importance of the firm size (Chudnovsky et al. 2006; Aboal et al. 2015). By this means, large firms are more prone to engage in innovation and in-house R&D activities (Benavente 2006; Aboal and Garda 2016; Broome et al. 2018). Such conclusions reinforce the Schumpeterian (1942) argument' that large size firms are more engaged in innovative activities and with higher market power (Benavente 2006). Nonetheless, one caveat is observed. Crespi et al. (2014) points out that R&D investments in the LAC are also more skewed and concentrated on a small number of firms.

Specifically, larger firms tend to innovate more frequently, and this effect may be due to the development of economies of scale and scope in the production of knowledge (Crespi and Zuniga 2012). Nevertheless, the major criticism here, is that large and highly innovative firms does not exceed 4.0% of firms (Fernandez 2017). In a first attempt to study vis-à- vis the manufacturing sector and focusing on the interaction of technological and non-technological innovation, Gallego et al. (2015) explains that the large firms with R&D division increased the probability to innovate; both in service and manufacturing sectors according to industry experts (Chudnovsky et al. 2006; Zuniga and Crespi 2013; Aboal and Garda 2016; Demmel et al. 2017). Importantly too, although, Aboal and Garda (2016) pointed out that firm's size is in general more important for manufacturing firms.

The innovation and R&D on low- and high-technology industries

Apart from the firm's size, the most relevant aspect is the technological and non-technological innovation activities (Aboal and Garda 2016). They discuss that a key point of the level of investment in technological innovations consists in the fact that non-technological innovations arise from less-formalized activities. So, for instance, in some cases patent protection is an important factor associated with innovation, but, as expected, it is more relevant for technological innovations and manufacturing industries (Aboal and Garda 2016).

Recently, the literature showed that innovation is still concentrated on low-tech and medium-low-tech Brazilian industries. By this means, non-technological innovation negatively affects the overall performance of the Brazilian companies, both in terms of profitability and productivity (Taveira et al. 2019). Although, Aboal and Garda (2016) identified that for manufacturing and service firms from Uruguay, both technological and non-technological innovation are positively associated to production gain. In the case of non-technological innovation—Argentina and Colombia—it leads to higher productivity (Crespi and Zuniga 2012). Specifically, Aboal and Tacsir (2018) identified that in the Uruguayan information and communication technologies (ICTs) firms, the innovation and productivity are more important in the services than in the manufacturing sector. In contrast, the weight of high-tech or more knowledge-intensive sectors in the Uruguayan economy is significantly lower than in most advanced economies (Aboal et al. 2015). It is worth noting, though, for manufacturing industries, that technological innovations are more relevant for productivity in Brazil (Taveira et al. 2019). Indeed, technological innovations are more important for the productivity, especially for small firms. In this manner, this occurred probably because SMEs are far away from the technological frontier, and improvements here generates bigger gains in productivity than in other firms (Aboal and Garda 2016).

Research question 1: How is the innovation output scenario across Latin American industries?

About the first question, the core of our answer can be found on the study of Fernandez (2017), providing a strong argument that firms displayed a very low or non-existent innovation level and did not reach a moderate or higher innovation level. For instance, Crespi et al. (2014, p. 38) explains that the innovation behavior differs across firms in LAC, which means that not all firms rely on innovation as a mean to increase economic performance, nor are all firms able to invest in innovation and transform internal knowledge into new competitive advantages. An additional explanation to such low innovation level is that, different from developed countries, most researchers are employed at higher-education institutions as opposed to public and private enterprises (Fernandez 2017).

In this respect, we claim that these reinforces the argument of Alcorta and Peres (1998 p. 877) referring that: "*In sum, LAC technological performance has been modest*". It becomes apparent that the overall pattern of Latin American and the Caribbean countries is modest, with low innovation level. In the case of the Caribbean, it shows the lowest rates of R&D investment

intensity by firms (Broome et al. 2018). Similarly, in Ecuador the firm' innovation patterns shows less intensive in R&D (Fernández-Satre and Reyes-Vintimilla 2020). That is, this is one of the major challenges in LAC, once, on average, firms in Latin America have smaller R&D investments over the time and do not have a properly quality certification (Hall and Maffioli 2008; Padilla-Pérez and Gaudin 2014; Pérez et al. 2018; Dobrzanski 2020). Additionally, the rate of return of R&D is expected to stay the same or to fall (Hall and Maffioli 2008). Indeed, this is not a surprise, given that the R&D expenditure/GDP ratio and the number of highly-qualified human capital, innovation and technology is still behind United States and OECD counterparts and also the Asian NICs (Arocena and Sutz 2000; Olavarrieta and Villena 2014; Fernandez 2017; Santi and Santoreli 2017; Broome et al. 2018).

Innovation and R&D and cooperation between firms

Networks of innovation are fundamental in determining firms' innovative performance (Cassiolato and Lastres 2000). Past researchers included network-level as an important strategy to develop innovation. Studies including the cooperation level, explains that there is little cooperation from abroad with LAC firms, except perhaps for marketing agreements (Alcorta and Peres 1998). Building on this point, innovation diffusion depends increasingly on access to advanced linkages between firms (Cassiolato and Lastres 2000). According to Alcorta and Peres (1998) there is an urgency to find technological partners and joint in these collaborations, since for example, LAC's innovative performance in high-tech products is not improving but seems to be worsening. Accordingly, it is necessary to create policies to allow private firms to enter in the virtuous circle of the networks that tie the innovation, production and trade in a globalized world (Moguillansky 2006).

Recent researches identified that firms cooperating in R&D with others have greater probability to invest in innovation, especially on SMEs (Aboal and Garda 2016). Interested in investigating the role of group-affiliated firms (GAFs) and standalone firms (SAFs) Castellacci (2015) pointed out specific institutional factors (e.g., financial, legal and labor market institutions) that affected both groups and the innovation relationship. They observed that the innovation propensity of GAFs is on average 10% higher than that of SAFs. Nonetheless, group-affiliated firms partly make up for weak or inefficient institutions as typically pointed out by the institutional void thesis (Castellacci 2015). Indeed, firms that cooperate, in particular with others in R&D, tend to have a greater probability of investing more in innovation (Aboal and Garda 2016). In this vein, Crespi and Zuniga (2012) argue that the cooperation (e.g., R&D

and product design) increases the propensity to invest in innovations, more specifically in—Colombia, Panama and Uruguay.

Extending this analysis, recent study offers a more detailed analysis showing that cooperative actions with different actors increases the probability of carrying out R&D (Mardones and Zapata 2019). In the same line, adjacent studies captured the impact of firm' collaboration (Goedhuys and Veugelers 2012; Kesidou and Snijders 2012; Aboal and Garda 2016) suggesting that partnership frequently implies improvements on the firm's innovation capacity. Undoubtedly, cooperation among firms shows a clear advantage. For instance, Kesidou and Snijders (2012) points out that innovative firms pursuing strategic indirect links with other firms resulted in better predictor of innovative performance than the direct local ties. We take the same position, once such arrangements, particularly in R&D, are fundamental for both manufacturing and service firms. Although, it seems to be particularly more pronounced in manufacturing firms (Aboal and Garda 2016; Broome et al. 2018). Consistent with this, Raffo et al (2008) pointed out that more attention should be paid to the complexity of the role of national and foreign business groups.

Employment quality and Innovation and R&D

For a long time, employment and innovation has been receiving attention (Castillo et al. 2014; Busom and Vélez-Ospina, 2017). This interplay is important for the firm innovation and productivity (Zuniga and Crespi, 2013; Gallego et al. 2015). For instance, they found evidences that firms with investments in knowledge are more able to introduce new technological advances compared to firms with lower productivity. Along similar lines, Aboal and Garda (2016) identified that product innovation leads to an employment growth in Uruguay. Apart from this, there is a commonality between several studies revealing that firms with high innovation have more employment power (Zuniga and Crespi 2013; Aboal and Garda 2016). Takin this into consideration, quality labor showed to be important, once innovation is more complementary to skilled than to unskilled labor (Aboal and Garda 2016) also a widely accepted tenet across the extant literature (Goedhuys and Veugelers 2012; Gallego et al. 2015). Specifically, using microdata from an innovation survey—Argentina, Chile and Uruguay (Elejalde et al. 2015) identified that most of the employment decrease was explained by non-innovators. However, human capital plays an important role in the decision to invest in innovation activities, but not necessarily in the amount of the investment (Ramírez et al. 2019).

In this vein, there are studies in the literature that shows how employees' skills are highly correlated with the probability of introducing all sorts of innovation in manufacturing firms (Busom and Vélez-Ospina 2017) specially product and process innovations (Castillo et al. 2014; Elejalde et al. 2015). Following this line, product innovation seems to have a differential effect on labor composition, showing larger positive effects on skilled labor (Aboal et al. 2015). In this vein, human capital might be a necessary condition to increase the innovative behavior of firms (Ramírez et al. 2019). Additionally, these authors explain that the literature points out that the percentage of university workers has a positive effect on marketing innovation in micro and small firms. In this view, Colombian SMEs that decided to invest in innovation activities are positively affected by the inclusion of trained human capital in the knowledge creation process compared to similar large firms (Ramírez et al. 2019). In contrast, process innovation appears to have a displacement effect on unskilled labor, but not on the skilled labor force (Aboal et al. 2015).

Other researchers studied Colombian enterprises—manufacturing and services—considering human capital as a determinant on the firm's investment decision (Ramírez et al. 2019). For instance, companies with reinvested revenues were more likely to gain market share and increase their number of employees (Yigitcanlar et al. 2018). However, when it comes to the Knowledge Intensive Service (KIS) firms, curiously skills are not significant (Busom and Vélez-Ospina 2017). So, they explain that might be attributed to the fact that very few firms in this sector deliver qualified employees. In other words, the lack of skilled human resources has always imposed serious constraints on LAC (Hall and Maffioli 2008). Specifically, in the case of several Caribbean countries the incidence of formal training in the small Caribbean islands is relatively low compared to Latin America (Mohan et al. 2018). Overall, innovation in product innovation is good for employment, however, reaping its benefits requires the presence of a workforce with the requisite skills (Crespi et al. 2019).

Exports and innovation and R&D in Latin American and Caribbean

In studies that includes foreign activities, we observed an important welfare-enhancing function in emerging economies that increases the export and economic development (Crespi and Zuniga 2012; Castellacci 2015). Building on this point, Bravo-Ortega et al. (2014) identified for Chilean firms that investments in R&D are considerably more likely to export, but the reverse is not true. These authors explained that the exporting does not stimulate investment in R&D, but exports and R&D have a joint effect on improving productivity. Overall, this suggests a

loop among R&D, productivity, and exports, also, a learning by exporting. So, for this and other reasons, such activity cause bidirectional causality between innovation and per capita economic growth in Chile (Avila-Lopez et al. 2019). In contrast, in the case of Brazil, international experience has a greater impact on export performance than innovation capacity (Oura et al. 2016). Other researches analyzing the context of the size of low-tech Peruvian firms, concluded that exports and investment intensity were the key determinant factors of Total Factor Productivity—TFP (Tello, 2015). Correspondingly, technological innovations are important for the productivity of small firms (Aboal and Garda 2016) and innovation has a significant impact on Peruvian firm's performance (Pino et al. 2016).

Moreover, Latin American countries have the challenge of improving environment to attract FDI (Avila-Lopez et al. 2019). As such, FDI is particularly central to developing countries (Guimón et al. 2018) and firms with foreign ownership shows a higher propensity to invest in innovation (Crespi and Zuniga 2012). In this line, the increased international openness (Goedhuys and Veugelers 2012) is important to foster and promote innovative and growth performance. For instance, researchers identified that on the Mexican industry, the expenditures on innovation by foreign companies are sometimes linked to product adaptation for domestic or export markets (Brown and Guzmán, 2014). Importantly, internationally engaged firms would be likely to engage in new product development (Broome et al. 2018).

Acquisition of technology and innovation and R&D in Latin America and Caribbean

Technological opportunities play a major role in research activities and innovation increasingly requires a combination of internal and external sources of knowledge (Benavente 2006). Innovation investments are made not only of spending in intangible assets such as R&D, other complementary inputs are also important (Crespi et al. 2016). However, innovation in domestic firms is largely characterized by the "new to the firm", for example, firms in less developed economies tend to imitate advancements in technology (Crespi and Zuniga 2012). In other words, firms only have capabilities to reproduce technologies and products already existent in the market (Dutrénit et al. 2019). Considering the role of machinery and imported technologies, the literature points out that investments in hardware, software, knowledge transfers and consultancy, affects positively the probability of obtaining product innovations—Uruguayan (Muinelo-Gallo and Martínez 2018). In contrast to the predominant thinking (Fernández and Gavilanes 2016; Frank et al. 2016; Taveira et al. 2019) of imported technology affecting negatively the firm's performance, technology acquisition enhances the probability of product

and/or process innovations (Chudnovsky et al. 2006). Moreover, technology intensive imports in Ecuador are not associated with superior performance, probably due the lack of absorptive capacity (Fernández and Gavilanes, 2016). Specifically, Hall and Maffioli (2008) points out that in many Latin American Countries, tertiary and secondary education are unbalanced, which also explains the limited Latin American capacity of absorbing new technology.

Studies including the role of technology acquisition in Brazil clearly identified that the innovation strategies were most strongly related to technology acquisition (Goedhuys and Veugelers, 2012; Frank et al. 2016; Taveira et al. 2019). So, for instance, acquiring know-how embodied in machinery and equipment, in combination with own internal development affects both process and product innovations. Furthermore, the reliance on strategies based on machinery and equipment acquisition is still the main investment category, and also is perceived as the most important innovation effort (Frank et al. 2016). Although the authors explain that machinery and equipment acquisition are still the most relevant input to innovate, it seems to be losing strength in the last years, while in-house R&D shows positive recovering.

Recent study offered a more detailed analysis on the firm' knowledge acquisition strategy (Mardones and Zapata 2019). For instance, they explain that the acquisition of external knowledge for Chile has a positive effect on the probability to have a R&D department. However, the R&D capacities tend to be highly concentrated within universities and public research institutes, also with low transfer of technologies from these institutions to the private sector (Mardones and Zapata 2019). In line with the institutional theory, it suggests that the related issue causes a strong barrier to innovation in developing countries. That is, removing barriers to innovation in low-productivity firms would yield high innovation returns (Busom and Vélez-Ospina 2017). So, for these and other reasons, the institutional theory (North 1990) poses that (e.g., excessive bureaucracy) can affect negatively the interplay between private and public firms to invest in innovations.

Many studies reported how the firm's performance reacts to the knowledge acquisition strategy. In terms of commonalities, Goedhuys and Veugelers (2012) explain that technology acquisition is most associated with innovative performance. In terms of differences, investment in machinery negatively affects the Brazilian company productivity while it does not affect company profit (Taveira et al. 2019). For example, in an innovation effort in Brazil, Santos et al. (2014) point out that the relationships between innovation variables and financial performance were not identified. Finally, there is also a key feature in stimulating the technology acquisition, not only for the purpose of firm innovation, but also to stimulate employment and job creation in Latin America (Zuniga and Crespi 2013).

Research question 2: What kind of strategies Latin American and the Caribbean countries are adopting to improve their domestic innovation performance?

Building on the related topics and arguments, we posit in the same direction of Katz (2000, 2001) and Alcorta and Peres (1998), once the recent structural reforms did not result in considerable past discontinuity. By these means, one of the main weaknesses consists in the absence of technological research, combined with the weak links in knowledge creation and dissemination, that has conditioned the survival capacity of Latin American enterprises in the global value chains that dominates international markets (Moguillansky 2006). A key point here is that R&D cooperation is a new in developing countries and the literature strongly recommended fully interaction and cooperation across firms (Cassiolato and Lastres 2000; Castellacci 2015).

In addition, the major criticism here is that firms in LAC have difficult to create new product and process innovations. For instance, there are several enterprises expanding in traditional sectors of the global economy (Fleury et al. 2013). Moreover, we take the same position of the literature that, in general, firms have a wrong perception about the usefulness of technology-acquisition (Frank et al. 2016). Unfortunately, this is one weak and also a common factor in Latin America, where firms use the new equipment to upgrade the outdated technology (Alcorta and Peres 1998). These insights suggests that, the choice to invest on foreign technology could cause a delusional effect with respect to the firm' innovation capacity. In other words, over the last couple of decades, developing countries are using the foreign technology inexpertly due to the lack of absorptive capacity and the emerging nature of their national innovation system (Fernández and Gavilanes 2016). Apart from this, it is necessary to comprehend a strategy based on the development of new technologies that will ultimately lead to truly and fruitful innovation (Frank et al. 2016).

Public support and innovation and R&D

Concerning the public policy, there is increasing interest in LAC in granting fiscal incentives to encourage R&D and innovation investments (Crespi et al. 2015, 2020; Aboal and Tacsir, 2018). As such, this is critical in the context of late-industrializing economies. In such an environment, the public policy interventions strategy plays a role in alleviating the financial constraints and market failures in innovation investments (Hall and Maffioli 2008; Goedhuys

and Veugelers 2012). In pursuing such a strategy, the literature has stressed that it is positively associated with the firm's decision to invest in innovation and R&D (Goedhuys and Veugelers 2012; Aboal and Garda 2016; González-Álvarez and Argothy 2019). For instance, firms that face such circumstances, invests significantly more in innovations than those who did not (Crespi and Zuniga 2012). An extension of the scope of public policy, consists that it can affect not only the intensity of innovation activity, but also the organization direction (Zuniga and Crespi 2013). Although, for example, in the case of Argentina public financing for private investment in innovation, it showed positive impacts on the firms' technological efforts intensity in monetary terms, although there are doubts about the public policy efficiency (Petelski et al. 2020).

Unfortunately, investing in innovation can be prohibitive for several firms in developing countries, especially for SMEs, once innovation is a costly process (Aboal et al. 2015). So, for instance, firms that face financing constraints are more likely to benefit from public policy (Busom and Vélez-Ospina 2017). In this vein, Yigitcanlar et al. (2018) explains that the private funding is deemed necessary for companies to finance their activities. In doing so, the decision to invest in innovation in the case of manufacturing firms are higher (Aboal and Garda 2016). In this context, there is a pervasive public support to encourage R&D activities and increase the likelihood of companies to implement a formal R&D department (Mardones and Zapata 2019). By this means, Crespi et al. (2015) explain that, the promotion of innovation program, such as the Colombia Innovation Agency (COLCIENCIAS) have promising implications to increase labor productivity and the TFP, mostly due to product innovation. In the same line, they explain that firms participating in a R&D support program in Chile increased the firm's TFP. Moreover, it is noteworthy that the public source of information positively impacts the probability of generating product innovations and the continuing innovating process (Muinelo-Gallo and Martínez 2018).

Elsewhere, although, Crespi and Zuniga (2012) highlighted the importance of investing in innovation and, at the same time, the difficulties, such as the weak link between firms and the national innovation systems, integrating scientific and technological resources into their innovation strategies. For example, Cuervo-Cazurra et al. (2019) explain that the focus of emerging market firms "uncommoditized" strategies is reinforced by the weak innovation systems of these countries. As such, several developing economies works with these policies separately (Castellacci and Natera 2016; Guimón et al. 2018). For instance, although, Moguillansky (2006) explained that policy should be aimed at developing cooperation between transnational and local enterprises, including several alternatives—e.g., supplier development

schemes, contributions to R&D, investment in the development and diversification of products, contributions to linkages between technological institutes, enterprises, and universities. Other researchers identified determinants that Peruvian companies may implement in presence of public support, such as R&D and industry effects, or external factors, such as cooperation and information sources, to activate organizational innovation (Pérez et al. 2019). More specifically, Paunov (2012) pointed out the importance of the public funding, since firms were less likely to abandon the investments in innovation during economic crisis due their difficulties in accessing external finance.

Institutional constraints and innovation and R&D

Several coordination failures may also require public intervention in a lack of technical information, the sunk costs nature of R&D and innovation investments, and the intrinsically high uncertainty of research and innovation outcomes (Crespi et al. 2015; Fernandes and Paunov 2015; Santiago et al. 2017; Broome et al. 2018). Reinforcing this argument, Hall and Maffioli (2008) explained that there are a large number of policy instruments commonly used to address appropriability and financial constraints in innovation (e.g., grants and matching grants, targeted credit, tax incentives, and the intellectual property system). For instance, in the case of the Intellectual Property Rights (IPR), it has the intends to alleviate market failures by providing a properly legal framework. Gómez-Valenzuela et al. (2020) explain that the intellectual property consists of the creation of the intellect of the people who operate individually or through organizations in the broad sense: companies, universities, and research centers. In this vein, the primary objective of the patent is to generate incentives for firms to invest in R&D activities (Milesi et al. 2013). As such, IPR can help safeguard and thus stimulate such investments (Crespi et al. 2020), although, an efficient IPR system requires strong institutional capacity and credible enforcement (Hall and Maffioli 2008).

Nevertheless, the IPR in LAC remains low, with a value around 0.21% (Pérez et al. 2018). Consequently, weak or incomplete IPR causes difficulty of keeping innovations secret (Crespi et al. 2020). Specifically, patent protection is more important for innovation in manufacturing than in services firms, considering the role of technological innovations (Aboal and Garda 2016). Overall, firms that have patents shows higher propensity to invest in innovation activities, although in some countries—Argentina—are not necessarily an indicative that firms invest more in innovations (Crespi and Zuniga 2012). Having observed this,

institutional factors strongly influence the decision to innovate at the company level (Pérez et al. 2019).

In this line, Pérez et al. (2018) explained that formal firms reduced their investments in R&D when the protection of IPR environment is underdeveloped. Additionally, more recent research shows that in the case of Peru, the interplay between public programs and large firms have negative effects on product innovation, due the low levels of political commitment, ineffective mechanisms, and institutional inertia characterized by high bureaucracy (Pérez et al. 2019). Indeed, policy interventions are, therefore, a plausible way to close this gap, for example through targeted specific subsidies (Crespi et al. 2020). Nonetheless, besides these arguments, it is noteworthy to mention that in the IPR literature it is currently not clear whether the patent systems contribute to innovation and productivity or even instead, limit it (Gómez-Valenzuela et al. 2020).

Research question 3: What kind of public policies are implemented to foster the development of innovation?

The fostering of firms' innovative activities has become increasingly present in public policies and public funding aimed to provide support to the productive sector of emerging and developed economies (Berrutti and Bianchi 2020). Despite recent high economic growth, Latin America still faces the challenge to reduce poverty and inequality (Crespi et al. 2019). In doing so, there is a great challenge for public policies to effectively increase firms' technology assets, facilitate access to finance for innovation and support more effective and articulated innovation systems. For example, firms in Mexico confront a heterogeneous set of financial and non-financial obstacles to innovation (Santiago et al. 2017). However, national innovation systems and public and private firms in LAC are still operating in an uncoordinated way (Dutrénit et al. 2019). For instance, national innovation systems with property configurations of institutions fosters the development of technology and innovation (Nelson and Rosenberg 1993). For this and other reasons, it is clear that there are several institutional and political problems in LAC (Castellacci 2015; Pérez et al. 2019). In this vein, the innovation intensity and performance of national innovation systems varies substantially across the region (Castellacci and Natera 2016). Consequently, firms in developing countries encounter difficulties in building working innovative networks in which information and knowledge helps them to invest in R&D (Raffo et al. 2008). As such, policy and business strategies designed to target innovation should pay

attention to the specificities of national innovation systems and firm's innovative behavior, customizing strategies accordingly (Crespi and Zuniga 2012).

Concerning the institutional sphere, on average, firms in Latin America have smaller R&D funding and investment (Pérez et al. 2018; Dobrzanski 2020). Although an increase in funds allocated to science, technology, and innovation can be noted, the level of investment remains very low (Dobrzanski 2020). Additionally, the investment deficit extends beyond R&D (Crespi et al. 2016). Specifically, there is consensus in the literature that the national innovation systems and IPR in LAC are weak and underdeveloped (Alcorta and Peres 1998). For instance, in Brazil, technological competences were not encouraged, if not inhibited by the local institutions (Fleury et al. 2013). In this vein, weak institutional environments increases the uncertainty because they create structures that are unfavorable to the fulfillment of contracts, increasing transaction costs and inhibiting innovation (North 1990). Extending to the financial context, creative and effective policy mechanisms are especially helpful to solve the SMEs constraints as well as innovation networks that include SMEs (Geldes et al. 2017). For instance, in Latin America the production structure is strongly dominated by SMEs (Crespi and Tacsir 2011). For this and other reasons, it is particularly important to continue investing in strong linkages with research universities, for joint R&D projects, and consequently getting attention and public support to ensure that firms continue to innovate (Chudnovsky et al. 2006; Gallego et al. 2015; Castellacci 2015; Mardones and Zapata 2019).

Building on these observations, the major challenge is the low-quality institutional factor that causes a negative innovation effect, specifically in environments with high bureaucracies (Pérez et al. 2019). For instance, a turbulent and unstable macroeconomic environment, and a lack of incentives for the production and utilization of modern technology in production activities, constitute the major explanation of why Latin American countries have not performed better in terms of productivity growth (Dutrénit and Katz 2005, p. 110). In this regard, institutional theorists have argued that in the case of Latin Region, the economic history showed a centralized government and bureaucratic traditions carried over from its Spanish/Portuguese heritage (North 1990, p.116). Finally, this proves why recent papers in the literature on economic growth and development, have emphasized the importance of economic institutions, and their useful framework for thinking about how economic institutions are determined and why they vary across countries (Acemoglu et al. 2005). In other words, institutions have important implications for the global economy (Nelson and Rosenberg 1993).

Discussions and future directions

Having examined these several topics and tackled our three questions, we have sufficient and necessary ground to respond the last.

Research question 4: What kind of lessons we can learn after four decades of investments in innovation and R&D?

It is well known that the Latin America is a large Region, certainly with substantive challenges, but also with great opportunities. Apart from this, firms are focusing to invest in innovation and R&D to gain advantage, reaching other developing economies to decrease the gap behind, for example, the Asian countries. We observed that after a phase of national incentives, early researches suggested that LAC showed some fair progress, but in a discreet way. For instance, none of the Central American countries offers tax incentives to specifically promote firms' R&D activities (Padilla-Pérez and Gaudin 2014; Gómez-Valenzuela et al. 2020). As such, the literature strongly highlighted that the degree of investments were very far away from developed economies. In addition, the determinants of innovation are not the same across countries with diversity of innovative behavior across Latin America (Crespi and Zuniga 2012). For instance, LAC economies have historically experienced a low participation of the productive sector in R&D investment (Hall and Maffioli 2008). Besides that, there is a considerable effort to innovate. Indeed, high economic growth, reduction of poverty and inequality are high in the policy agenda in Latin America (Crespi and Tacsir 2011) and the discussion regarding the construction of policy mixed to foster innovation is now receiving attention (Gómez-Valenzuela et al. 2020). Indeed, the public sector played the most important role in the development of national innovation systems (Cassiolato and Lastres 2000; Berrutti and Bianchi 2020). Consistent with this, Arocena and Sutz (2000) pointed out that the relation between firms and knowledge production institutions is a key aspect of the innovative landscape.

We identified the positive result for innovations in cases where local firms cooperate or grant subsidies. As such, innovation and cooperative behavior are deeply affected by the evolution of institutions and institutional change (Cassiolato and Lastres 2000; Gómez-Valenzuela 2015). In particular, interaction between external agents shows a virtuous process of developing new innovations (Moguillansky 2006). Nonetheless, we noted that there is still a low level of cooperation between Latin American companies to share knowledge and

employees among themselves, going a different direction of more developed and integrated regions, such as OECD countries. Another shortcoming is that the literature shows that SMEs are struggling to survive and to maintain their innovation activities; in some way with informal activities. In general, researches appointed there is a productivity gap, resource restraint and low R&D subsidies to SMEs.

For instance, in the case of a small Caribbean island, several firms in the region showed obstacles to in-firm training, including firms that cannot afford the optimal training costs (Mohan et al. 2018). The literature has shown the importance to develop industrial polices to develop SMEs and cooperate with other industries, sharing information and knowledge to improve and advance a step forward to a more strengthening technology intensive industry. Extending these points, it is important to analyze the impact of public policies aimed at Latin American innovation-driven industries and R&D, especially financing SMEs and young firms (Aboal and Garda 2016; Crespi et al. 2016; Oura et al. 2016; Geldes et al. 2017; Santi and Santoreli 2017; Mohan et al. 2018). For instance, Mardones and Zapata (2018) explain that SMEs that have some type of expenditures on innovation activities in previous year are more likely to obtain public support for innovation. Furthermore, the context of IPR is crucial, because weak or incomplete IPR causes difficulty of keeping innovations secrets (Crespi et al. 2020). Specifically, failing to protect firm knowledge when private firms are launching their R&D programs, may weakening the firm' innovativeness (Hall and Maffioli 2008).

In the case of imported machinery is observed a large incentive for firms. Nonetheless, after several decades, LAC continues to predominantly adopts the strategy to import the machinery and technology, nevertheless with wrong perception to innovate and develop their own products and process. Specifically, firms have also difficulties translating the imported technology into new products and process to the market. This in turn means that firms may face problems associated to the lack of absorptive capacity. Indeed, it cannot be neglected that innovation have effects in terms of employment at the level of the firm (Aboal and Tacsir 2018). By these means, governments should promote access to highly educated academic human capital and training that provides employees with novel capabilities and skills that complement the acquisition of technology (Hall and Maffioli 2008; Broome et al. 2018; Crespi et al. 2019). In cases where countries have managed to combine imitation and innovation policy has experienced a higher rate of growth (Castellacci and Natera 2016). Moreover, since enterprises also foster and develop innovations, it is important to promote them (Avila-Lopez et al. 2019).

Along related lines, it is necessary to consider specific R&D-related FDI in specific sectors (Guimón et al. 2018), once, for example, the manufacturing, service and agriculture

sectors will tend to have different innovation dynamics (Geldes et al. 2017). As such, governments must evaluate the results in order to reduce the risk of wasting money and have no impact on innovation (Avila-Lopez et al. 2019). Although it is important that policymakers consider the right amount of investments and subsidies (Berrutti and Bianchi 2020). All countries firms that invest in knowledge are more able to introduce new technological advances and those who innovate have higher labor productivity than the rest of firms (Crespi and Zuniga 2012). Finally, it is important to keep in mind that firms need to engage and invest in innovations even on a small scale (Chudnovsky et al. 2006) to prevent them to losing their innovative capacity and stop the process of innovation.

The foregoing review and questions clearly shows the LAC innovation and R&D scenario. Nonetheless, this systematic literature review is not limited to consider only the past researches, but to go beyond, because in such circumstances it is not the past that matters, the wisdom is on the future (Ubaldi 1959). By this means, we are therefore suggesting in Table 3, several contributions for future research studies. However, other core questions emerged from the literature review. Specifically, it is not possible to stress an entire future agenda and other research' insights. For this, to move the field forward, we hope this cognizant review guides researchers much more by their own researchers' creativeness.

Limitations

This study it is not free of limitations. First, despite we investigated large and significantly scientific electronic bases, other articles were not captured in our literature review. Second, we restricted our analysis focusing only on manufacturing industries in Latin American and the Caribbean countries. We believe that the rationale to adopt only the manufacturing industry is valid, nonetheless ceil the role of innovation and R&D in LAC, excluding the solely researches in service firms. Moreover, we adopted the SJR rank analyzing only peer-reviewed journal articles with a minimum of 20 points on the *h.index* to ensure the journal quality. Although this procedure benefits from the quality of the analyzed articles, this could narrow our sample causing a possible misty on the results.

Table 3 Future research direction and insights

Future research guidelines and insights	**α → β → φ → β →**
→	*Theory gaps*
	α Use the institutional theory to deeply understand how innovation and R&D are affected in Latin countries by formal and informal institutions.
	α Use the institutional theory as the main argument to sustain and develop innovation, R&D and the National Innovation Systems in LAC.
→	Methodology Gaps
	α Use more refined methodologies and models across the CDM literature.
	α Researchers may consider different measures of innovation and other econometric model to measure the innovation output.
→	*Country gaps*
	α Encourage studies to analyze single country contexts.
	α More researchers using micro data in small countries, especially the Caribbean Region.
	α Why some countries do not report evidence of any relationship between innovation and productivity? Has this to do with the nature of innovations in terms of the level of innovativeness and technological content? (Demmel et al. 2017)
→	*Other research gaps*
	α Explore the role of state-owned enterprises in LAC to conduct the innovations.
	α Compare the results obtained for public enterprises with those for private firms (González-Álvarez and Argothy 2019).
	α Explore the role of group affiliation firms in LAC.
	α Pay more attention to other innovation activities beyond R&D (Crespi and Zuniga 2012, Aboal and Garda 2016; Aboal and Tacsir 2018).
	α Lack of research considering collaborations between SMEs and universities.
	α Lack of research considering breakthrough innovations and cooperation.
	α Compare the firm innovation and R&D in low and high IPR configuration.
	α Bibliometric, systematic and integrative literature reviews using other scientific bases are welcome.
	α Investigate the SMEs context to understand why is difficult to finance their innovation activities.
	α Investigate the role of patent protection and the firm ability to innovate.
	α Compare the firm formal and informal activities and the innovation outputs.
	α The role of international networking as substitute for national deficiencies also requires more analysis (Raffo et al. 2008).
	α The amount of innovation subsidies for innovation can be a scale barrier and future researches should include a cost estimation of a minimal investment threshold (Berrutti and Bianchi 2020).

Conclusions

The foregoing research had the objective to shed more light about the innovation and R&D thematic in Latin America and the Caribbean countries, tackling the following questions—*How is the innovation output scenario across Latin American industries? What kind of strategies Latin American and the Caribbean countries are adopting to improve their domestic innovation performance? What kind of public policies are implemented to foster the development of innovation? What kind of lessons we can learn after four decades of investments in innovation and R&D?* Considering these propositions, we linked each of them comparing and criticizing to find the answers related to the actual scenario of innovation and R&D in LAC.

Our systematic literature review makes several contributions. Specifically, we introduced an innovation explanation reconceptualizing the most famous metaphor of Joseph Schumpeter, using a scientific and philosophical approach. Furthermore, we provided a picture of the antecedents and the most recent trends. Specifically, the literature analysis shows that it is clear that there is a truly and increasing progress on innovation and R&D in Latin American and Caribbean manufacturing industries. Nevertheless, as shown in the historical overview, over the last 40 years, innovation and technological gaps remains a problem. The literature demonstrates significant short-comings related to the innovation and R&D in Latin American and Caribbean countries. In a general conclusion, one of the major issues in LAC that affects the development of innovation and the R&D investments are settled in the institutional theory. We posit our conclusions that governments may overcome the issues by promoting new and more efficient administrative reforms, new policies and, also, the industry integration in a more cooperative way.

Finally, to accomplish this research, we return to the beginning in our philosophic approach to explain the "creative destruction" and how extraordinary it is for all economies and enterprises. In conclusion, the research reiterates the classical metaphoric phrase, just in time, when the innovation cycle, once more, reaches the *alpha* (α) pinnacle. Meanwhile, there is too much to understand about developing economies, regarding Latin America and the Caribbean countries. Clearly, further research is necessary to explore the innovation and R&D drivers in LAC. In doing so, as researchers, we hope the foregoing inception stimulates and encourage academic students reflects and go further to maintain the giant crumbling' metaphor, extending and improving the scientific knowledge with new and prominent questions as well as "new" evidences.

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ARTICLE 2 – INTELLECTUAL PROPERTY RIGHTS PROTECTION AND COUNTRY INNOVATION PERFORMANCE: EVIDENCE FROM LATIN AMERICA AND CARIBBEAN

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Intellectual Property Rights Protection and Country Innovation Performance: Evidence from Latin America and Caribbean

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Abstract

Theoretical and empirical literature have argued about the importance of international agreements and local institutions to strengthen intellectual property rights (IPRs). Strengthen IPRs may influence a country's innovation performance through domestic and foreign innovation base activities. Hence, we analyze how the role of country intellectual property rights protection affects innovation performance. Developing a unique IPRs protection index for 15 Latin American and the Caribbean countries from 2009 to 2018, the results show that the strengthening of IPRs brings positive gains for domestic and foreign innovation activities in a given country. Nonetheless, the nonlinearities show complex differences. In contrast, the domestic innovation shows a U-shaped pattern while the foreign innovation activity showed an inverted U-shaped pattern in the presence of strong IPRs protection. Therefore, it is necessary to consider the positive and negative externalities of an unbridled IPRs policy in developing economies. Our findings suggest that, perhaps, a more balanced IPRs protection is preferable than an unbearable high IPR protection policy aiming for development and technology transfer in knowledge and globalized environment. This study contributes to the long-standing IPRs debate in developing economies and offers significant theoretical and policy implications to keep making progress and sufficiently advance any technological change in developing economies.

Keywords: Intellectual Property Rights. Innovation performance. TRIPS Agreement. USTR Agency. Foreign direct investment. Developing countries.

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1 Introduction

Intellectual property rights have become a key institution to foster the development of cutting-edge inventions by R&D expenditures (Arrow, 1962; Varsakelis, 2001; Wang, 2010; Athreye et al., 2020). Now more than ever, the globalization of innovations has been increasingly directed towards developing countries (Casanova & Miroux, 2019; WIPO, 2019). However, despite the upswing movement to the South, developing countries continue to face low institutional quality issues (e.g., weak intellectual property rights– IPRs) that may discourage domestic and foreign innovation activities (Maskus, 2000; Khoury & Peng, 2011; Maskus et al., 2019; Papageorgiadis & Sofka, 2020). Meanwhile, in a continuum effort to improve the domestic base innovation and to attract foreign capital, Latin American and the Caribbean (LAC) countries started to follow up multilateral standards, such as the formal Trade-Related Aspects of Intellectual Property Rights (TRIPS) of the World Trade Organization (WTO) and the United States Trade Representative (USTR), part of an informal U.S Government agency.

These IPRs initiatives are crucial to overcoming the market and institutional failures to foster the host country's innovation performance through domestic and foreign activities (Smarzynska-Javorcik, 2004; Papageorgiadis & Sharma, 2016; Lee et al., 2018). The existing theoretical and empirical studies have highlighted that the strength of IPRs encourages R&D investments through domestic and foreign innovation activity to knowledge transfer through FDI inflows (Arrow, 1962; Varsakelis, 2001; Kanwar & Everson, 2003; Khoury & Peng, 2011; Papageordiadis & Sharma, 2016; Christopoulou et al., 2021). The rationale behind this knowledge consists of the conventional doctrine that "the higher the level of IPRs protection, the better" (Peng et al., 2017, p. 903). Unfortunately, in the IPRs' world, there is no truth universally acknowledged that advocates this assumption, which to some extent arguably results in controversial arguments concerning the strengthening of IPRs and their benefits to the country's innovation and growth (Athreye et al., 2020; Neves et al., 2021).

On the one hand, researchers explain that strong IPRs increase the levels of domestic innovation (Park, 2008; Coe et al., 2009; Willoughby, 2018). On the other hand, strong IPRs in developing economies could undermine domestic innovation, once only countries with sufficient technological frontier can take benefits from a stronger IPRs system (Allred & Park, 2007; Kim et al., 2012; Sweet & Maggio, 2015; Klein, 2018; Zhao, 2020). This is because IPRs policy can act as a double-edged sword (Wu et al., 2019). Thereby, strengthening IPRs may

particularly benefit foreign patent applications and FDI inflows within a country or worsen the local domestic innovation due to the low technology capacity in several developing economies.

In this regard, and despite the concern about IPR regimes, the empirical and theoretical literature is still controversial in understanding (a) how strengthening IPR affects innovation performance in developing economies. As far as we have known, much less attention has been paid to understand (b) how the national IPRs protection impacts host country innovation by domestic and foreign activities within the country. Given these ambiguous questions, we continue to extend past research to analyze an under-researched region – Latin America (e.g., Khoury & Peng, 2011). Focusing on Latin American and the Caribbean countries, our study examines how the role of country intellectual property rights protection affects innovation performance. While the country's institutional economics is broad (North, 1990), we draw on one specific institutional setting – intellectual property rights protection. From this theoretical perspective, we develop a unique IPR protection index to assess the distinct impact on domestic and foreign innovation base activity and their causal relationship in the country's innovation performance.

The research offers two primary contributions. First, extending the IPR protection to domestic innovation activity context is necessary once there has been considerable debate tightening IPR on developing countries (Lall, 2003). Equally important, few studies consider domestic and foreign innovation activity in the same analysis (e.g., Khoury et al., 2014; Willoughby, 2018). Thereby, we put into the empirical analysis the LAC countries because some of legal institutional aspects (e.g., IPRs and investments in innovation) vary by countries development and geographic regions (Maskus, 1998; Lee et al., 2018; Stel et al., 2019; Christopoulou et al., 2021; Neves et al., 2021). Looking beyond, we continue to research a region in which countries are increasing investment toward innovation activities through R&D expenditures and at the same time show a mix of weak and strong IPRs regime (e.g., Khoury & Peng, 2011; Lee et al., 2018; Viglioni et al., 2020).

Second, we followed Park's (2008) suggestion to adopt patent rights as an independent variable. In doing so, through several components from the Institutional Pilar from the World Economic Forum, we contribute to developing a unique index – Intellectual Property Rights Property Index (IPRPI) to explore the relationship between strengthening IPRs protection and domestic and foreign innovation activities. Hence, a better understanding of the effects of weak or strong IPRs protection is potentially informative to policymakers interested in foster the country's R&D investments by domestic and foreign activities. Our study is also relevant from a theoretical standpoint once we adopt both formal and informal structures (North, 1990). Thus,

we look forward to building on earlier scholarship (e.g., Smarzynska-Javorcik, 2004; Papageordiadis et al., 2013; Papageordiadis & McDonald, 2019) positing two specifics IPRs institutions to controls the country IP protection. First, as a formal institution, we chose the levels of *de jure* legal protection "Law on the books", (TRIPS agreement). Second, as an informal institution, we chose the quality of *de facto* enforcement "Law in practice" (USTR's Special 301).

The article is organized as follows. Section 2 provides the theoretical background and hypotheses development, with the respective grounding literature. Section 3 provides the methodology, which consists of data, variables description, and the model specification. Section 4 discusses the descriptive statistic and results. Finally, the last section of the paper presents the conclusions and further implications for future researches.

2 Theoretical background – Intellectual property rights across Latin America and the Caribbean countries

Over the last decades, there has been an increasing international interest in protecting IPRs and understanding how they affect the generation of innovation and technology transfer across different nations (Maskus, 1997; 1998; Neves et al., 2021). This is an evolution strongly influenced by the World Trade Organization (Papageordiadis & McDonald, 2019). Together with the World Intellectual Property Organization (WIPO), the bilateral standards of protection TRIPS agreement – require and support that country members develop a balanced and effective IP system (Papageordiadis & McDonald, 2019). Aside from several important WTO agreements[10], the TRIPS from the Uruguay Round of trade of negotiations, which begun in 1986 and concluded in 1994, was a notable foundation of the new WTO, to include the formal integration of IPRs into international trade rules (Maskus, 1998; Athreye et al., 2020).

As a formal institution, TRIPS consists of the most comprehensive multilateral agreement on intellectual property since the Paris Convention (1883), playing a central role to facilitate trade in knowledge, induce more innovation and creativity, cross country economic transactions, as well as a solution on a dispute over IP (Sweet & Maggio, 2015; Brandl et al.,

[10] Examples of WIPO-Administered Treaties adopted by several Latin American and Caribbean countries: Patent Law Treaty – PLT (2000); Beijing Treaty on Audiovisual Performances (2012); WIPO Copyright Treaty (1996); Trademark Law Treaty (1994); Madrid System (1991); Berne Convention (1886).

2019; Neves et al., 2021). By definition, TRIPS is stronger, binding and deeper than several other agreements, such as Paris Convention (patents) and Berne Convention (copyright), with costs and consequences of non-compliance (Athreye et al., 2020). Since then, many developing countries have substantially strengthened their intellectual property regimes (e.g., TRIPS agreement and others) in response to growing pressures from advanced economies (Lee et al., 2018).

As part of the Washington Consensus – LAC countries joined in several IPR standards with coordination and assistance of international multilateral organizations such as the WTO and WIPO (Khoury & Peng, 2011). Thus, in recent years the role of science and technology (S&T) in growth has extended and gained pre-eminence in Latin American and the Caribbean countries' public policy (Hall & Maffioli, 2008). Through TRIPS introduction[11], the IPRs system can increase in strength, and developing economies can foster innovation (Maskus, 1998; Park, 2012). In the case of R&D expenditures, IP reforms contribute to patents in developing economies because WTO members can no longer exclude any technology area – e.g., computer software and databases, chemicals, pharmaceuticals, and biotechnological products (Maskus 1997; Park, 2008, 2012). Taking in other perspectives – the foreign innovation activities, TRIPS has a pro-FDI view and allows Multinational Enterprises (MNEs) to further invest abroad with less uncertainty (Khoury & Peng, 2011; Christopoulou et al., 2021).

Aside from TRIPS, the establishment of the USTR by the U.S Government agency started in 1989 to develop trade policy with issues in several areas regarding trade organizations, such as WTO and their trade-related intellectual property protection. As an informal institution, the USTR began annually issuing the "Special 301 report", essentially a global report card that evaluates all countries' IP practices and places those judged to be problematic on the "Watch List" or "Priority Watch List" (Athreye et al., 2020). At the same time, the USTR watch and priority list annually place several Transition and developing

[11] Hall and Maffioli (2008) argue that LAC economies have not yet developed IPRs systems in line with the TRIPS agreement. However, we note that several Latin American and the Caribbean countries were accepted on the TRIPS agreement after 2009. Although several developing countries signed the TRIPS agreement on its creation, many countries lacked a minimum of intellectual property protection and had to update their institutional environment. Maskus (1997; 1998) explain that countries are also free to accelerate their adherence to TRIPS. This is one reason why several developing economies were late accepted as TRIPS members (Brandl et al., 2019).

economies from the world, especially from Latin American countries. Specifically, the USTR has important implications once a large group of developing countries was reluctant to TRIPS agreement (the context of IP and trade rules[12]). Although developing countries lost this fight, they were directly targeted by the USTR (Athreye et al., 2020). In developing economies, regarding Latin countries, the USTR shows positive steps in IP protection[13]. For instance, due to the United States' concern regarding inadequate and ineffective IP protection and enforcement, the U.S Government includes conferences and training in the Dominican Republic, Trinidad and Tobago, Barbados, and Jamaica, leading to heightened expertise and awareness (USTR, 2018).

Moreover, the 2015 "Special 301 report" documented that "In Fiscal Year 2014, U.S. Immigration and Customs Enforcement (ICE) Homeland Security Investigations (HSI), through the National IPR Coordination Center (IPR Center), and in conjunction with INTERPOL, conducted law enforcement training programs in France, Qatar, and China. ICE-HSI trained officials and police officers from Korea, China, Greece, Spain, Morocco, Algeria, France, Qatar, Ghana, Botswana, Gambia, Liberia, Nigeria, Rwanda, El Salvador, Colombia, Chile, Paraguay, Peru, Uruguay, Romania, Bulgaria, Ukraine, Thailand, Brazil, Honduras, Costa Rica, Venezuela, Benin, Guinea, Senegal, Togo, Curacao, Pakistan, Sri Lanka, Laos, and Turkey" (USTR, 2013, p. 17). Eventually, negative points also have been highlighted – "Venezuela's Autonomous Intellectual Property Service (SAPI) has not issued a new patent since 2007, and patent applications have dropped by over 50 percent between 2015 and 2017." (USTR, 2018, p. 64).

In recent years, Latin American and the Caribbean countries are part of several innovation-oriented conventions. As such, the Latin region showed considerable growth and investments in R&D, surpassing from the US$ 43 billion mark in 2008 to more than US$ 63 billion in 2017 (RICYT, 2019). According to a study done by the RICYT (2020), in 2018, the investments in R&D in LAC surpassed the US$ 90 billion, a growth 28 percent larger when compared to the US$ 70 billion in 2009. In addition, since 2000, LAC countries have

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[12] For a more detailed TRIPS and USTR history, we suggest checking Maskus (1997, p. 684), Brandl et al. (2019) and Athreye et al. (2020).

[13] The use of an informal agency, such as USTR for control, "Law in practice", is necessary to support formal institutions, such as (TRIPS), "Law on the books", because agreements such as TRIPS did not imply set obligations regarding the effectiveness of IP, and thus, problems related to the effectiveness in IPRs protection can emerge (Papageorgiadis et al., 2013; Papageorgiadis & McDonald, 2019).

experienced an increase in their scientific publication (around 36%), doubling their share of patents since the 1970s (WIPO, 2019). Nonetheless, compared to developed countries, such as the U.S, and developing economies from Asian Region, the R&D investments in LAC still remains low (Crespi et al., 2014). In the case of foreign patent applications in LAC, a significant number (80% of patent applications) corresponded to foreign companies that protect products in the region's markets (RICYT, 2020). In terms of FDI inflows in Latin America and the Caribbean (2013-2019), on average, increased by 1,71 percent and grew 10 percent in 2019, reaching the US$ 164 billion mark, driven by increased flows to Brazil, Chile, and Colombia (UNCTAD, 2020).

Taking these examples of international conventions and the effort from Latin economies in the last decades to invest in innovation through domestic and foreign activities, it is critical to advance toward IPRs protection in developing economies to foster the country's innovation, such as R&D investments. On the other hand, as outlined in the Introduction, there are mixed conclusions on strengthening IPRs in developing countries (Smarzynska-Javorcik, 2004; Sweet & Maggio, 2015; Lee et al., 2018; Athreye et al., 2020; Neves et al., 2021). Conceptually, we extend the following section to theorize and empirically assess the country's innovation performance through the relationship between intellectual property rights protection and domestic and foreign innovation base activities.

3 Hypothesis development

3.1 Intellectual property rights protection and country' innovation performance

Domestic innovation activities constitute a prominent way to increase the overall innovation ratio within a country. Country innovation bases can be related in multiple ways. The literature commonly recognizes patent applications, the rate of tertiary education and the proportion of scientific self-citations as important indicators of innovation activity (Varsakelis, 2006; Wang, 2010; Khoury & Peng, 2011; Crespi et al., 2014). This is because the domestic innovation activity, such as patent applications, simultaneously, or at the very least, conducts the country's R&D expenditures.

Considering the domestic base innovation and the country's educational quality, Coe et al. (2009) documented that countries with high-quality educational systems tend to benefit more from their own R&D efforts. Moreover, investigating 29 countries, Varsakelis (2006) found that quality of education increases the output of innovation by patent activity. Similarly, analyzing 26 countries from the OECD, Wang (2010) identified that tertiary education and

scientific researchers in a country leads to positive effects on the country's R&D intensity. Applying a fine-grained index to measure the country's domestic innovation, Khoury and Peng (2011) showed that local scientific publications and patent applications are an important component to foster innovation base level in countries from LAC.

Nonetheless, the literature always emphasizes that developing economies do not have sufficient knowledge structure to develop their own innovations and increase their R&D intensity (e.g., Sweet & Maggio, 2015; Stel et al., 2019). This is because several developing economies (e.g., countries from LAC) only have an R&D effort and innovation base activity oriented toward copying innovation from the others (Maskus, 1998; Hall & Maffioli, 2008; Viglioni et al., 2020). Considering that the literature is ambiguous about developing economies (e.g., LAC countries) have or do not have a sufficiently domestic innovation capacity to increase the country's innovation performance, we propose the following hypothesis:

Hypothesis 1a. The greater the domestic innovative activity (*ceteris paribus*), the higher the innovation performance within the country.

Regarding intellectual property rights in a given country, patent laws and other protections help to reduce the uncertainty that surrounds the possibility of appropriation (Zhao, 2006; Wang, 2010). In this line, Arrow (1962) argued that IPR encourages innovation and plays an important role in R&D activities. Varsakelis (2001) put forward a similar argument, showing that countries with strong patent protection tend to invest more in R&D. Indeed, previous research assumes the IPR becomes the base and the motivation for technological progress and new knowledge (Neves et al., 2019). Nonetheless, in developing economies, a strand of the literature argued that the stronger IPR regimes might lead to fewer patents being obtained (Papageorgiadis & Sharma, 2016), or, at the very least, results in a decrease in the country's innovation output, such as the R&D intensity.

This is because developing economies lag behind developed countries in innovation investments, such as R&D (Crespi et al., 2014). Thus, if the country has weak innovation base activities, the increase of IPR protection will not necessarily lead to increases in the country's innovation performance. This is confirmed by Sweet and Maggio (2015), where stronger IPR engender higher levels of economic complexity, proxied by exports of technology. Nonetheless, the authors noted that only countries with an initial above-average level of development and complexity could reap the fruits of strong IPR protection. This is in line with Lee et al. (2018),

once developing countries with sufficient capacity to innovate and IPR protection can deliver tangible rewards such as domestic innovation and technology diffusion.

Nonetheless, the literature debate constantly emerges about the nonlinear relationship between IPR and country' innovation. For instance, based on the dataset of 62 developed and developing countries, Hudson and Minea (2013) observed a U-shaped relationship that IPR exerts over the country's innovation. In such circumstances, copying and imitating by reverse engineering is preferable in lagging developing economies with weak IPRs, where local firms in the early stages of development can build their technological capabilities, as well as many Asian "Tigers" experienced much before they become more IPRs friendly (Lall, 2003; Neves et al., 2021).

Moreover, evidence suggests the opposite. Other studies observed an inverted U-shaped relationship between strengthening IPR and innovation (e.g., Allred & Parl, 2007; Furukawa, 2010; Stel et al., 2019). This is because the negative nonlinear relationship between IPR protection and innovation suggests that too strong as well as too weak IPR protection hurts the incentive to innovate (Furukawa, 2010). Similarly, analyzing 32 European countries, Stel et al. (2019) concluded that too strict IPR legislation may hamper the diffusion of knowledge created by R&D. Although both arguments seem valid, we still expect the relationship between the country's IPR protection and its innovation performance to be nonlinear and follow a positive curvilinear form for developing economies.

Hypothesis 1b. As the country's intellectual property rights protection increases (*ceteris paribus*) and interact with the domestic innovation activity, the country's innovation performance assumes a U-shaped pattern.

3.2 Intellectual property rights protection and country innovation performance through foreign innovation activity

While the domestic innovation base can increase the country's innovation performance, the context of foreign innovation activities within a country is also crucial for host countries to achieve an increased innovation level. In this vein, it is well acknowledged that FDI is an important driver of international business activities (Smarzynska-Javorcik, 2004; Khoury & Peng, 2011). Through FDI inflows, foreign activities strongly contribute to investment and economic growth in developing countries by bringing capital, high-technology products,

managerial and other skills and know-how, and marketing networks from advanced economies (Wang, 2010; Lee et al., 2018).

To enhance FDI inflows, local governments improve institutions by strengthening the enforcement of IPR (Liu & Li, 2019). This is because developing countries that offer IPR-related incentives may be able to attract more inbound FDI through MNEs' pool of knowledge (Khoury & Peng, 2011; Christopoulou et al., 2021). For instance, Lee et al. (2018) suggests that in institutionally strong countries, IPR protection promotes FDI by reducing illegal imitation and freeing up more resources for MNCs. This is not coincidental, as openness to FDI in developing economies tends to force domestic producers to improve quality, reduce management inefficiencies, and increase the rate of R&D investment (Wang, 2010). Furthermore, this helps domestic firm's investment in R&D, once they can aim to invent around and develop similar IPR assets to those of the MNEs, without legal infringement (Christopoulou et al., 2021).

Nonetheless, in attracting FDI, developing economies with underdeveloped legal institutions need to choose between developing institutions to attract more FDI or weak IPR protection, which in the case of the previous one will discourage local R&D and knowledge spillovers (Liu & Li, 2019). Despite these rationales, the results of empirical studies exploring the impact of FDI inflows, IPR protection and domestic innovation investments through R&D varying from case to case (Smarzynska-Javorcik, 2004; Wang, 2010). For instance, the studies explain that more FDI is associated with the simultaneous presence of a large domestic innovation base and MNE-supportive IPR policies (Khoury & Peng, 2011).

Inspired by this, a nation with stronger IPRs could receive more FDI because intellectual property protection increases the value of a foreign firm's unique asset (Maskus, 1997). For instance, Lee et al. (2018) found that stronger IPR protection in developing countries would enable developed countries to capture more of the fruits of their R&D and other innovative activities. Otherwise, a weak IPR regime is favorable to imitation and makes a host country less attractive for foreign investors (Smarzynska-Javorcik, 2004). Taken together, in both domestic and foreign innovation activities, we expect that foreign innovation base activities tend to benefit more from the strengthening of IPRs (inverted U-shaped) than the domestic innovation base (that shall have a positive effect but lower nuances for the domestic innovation base):

Hypothesis 2a. The greater the foreign innovative activity in the host country (*ceteris paribus*), the higher the innovation performance within the receipt country.

Hypothesis 2b. As the country's intellectual property rights protection increases (*ceteris paribus*) and interact with the foreign innovation activity, the country's innovation performance assumes an inverted U-shaped pattern.

Hypothesis 2c. As the country's innovation performance increases, strengthened by the relationship between the local intellectual property rights protection and foreign innovation activity within a country, the same relationship is lower or no longer observed for domestic innovation activity.

4 Methodology

4.1 Data

In order to test the hypotheses, we collected information from several sources, consisting of the integration of three databases. First, the annual country data were drawn from RICYT (http://www.ricyt.org). For example, a key objective of the RICYT is to provide rich data of science, network and technology indicators in Latin America and the Caribbean countries (e.g., R&D expenditures and personnel, Ph.D. graduates, scientific bibliometric indicators, patents granted and requested, and others). The second source provides several country Institutional indicators from the Worldwide Economic Forum (www.weforum.org) extracted from the Global Competitiveness Report. Finally, the third source of data comes from World Development Indicator from the World Bank (www.worldbank.org) to obtain country-level economic information (e.g., inflows of Foreign Direct Investment, Exports and imports, technology exported and country's inflation GDP deflator).

We included the following countries in the sample, which are located at Central American and South America. After removing the missing values, considering there are differences between the country information's across these bases, the final sample consists of 15 Latin American and Caribbean countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay and the Bolivarian Republic of Venezuela). In line with Khoury and Peng (2011), the choice to restrict the sample to Latin countries permits us to control the regional effect. After accounting for missing values, the unbalanced panel data resulted in a sample of 15 countries, which spans from 2009 to 2018 (115 observations). Table 1 provides the mean values based on panel data from 2009 to 2018 of each country's dependent and independent variables measured in the sample.

Table 1 Descriptive data by country

Country	Acceptance on TRIPS[e]	R&D/GDP (Million US$)[a]	Domestic Patents[c]	SCI Public[b]	Foreign Patents[d]
Argentina	Oct 2011	0.0058	598,700	24.927	3.782,600
Brazil	Nov 2008	0.0121	7.750,778	23.486	23.278,889
Chile	Jul 2013	0.0036	379,800	47.614	2.315,800
Colombia	Aug 2009	0.0025	305,300	9.817	1.850,400
Costa Rica	Dec 2011	0.0050	29,900	13.804	585,600
Ecuador	—	0.0040	10,250	3.248	547,750
El Salvador	Sep 2006	0.0010	29,700	1.190	226,900
Guatemala	—	0.0004	6,600	1.371	321,100
Mexico	May 2008	0.0042	1.214,800	12.437	14.674,900
Panama	Nov 2011	0.0013	26,333	12.124	314,333
Paraguay	Jul 2018	0.0010	17,500	2.285	348,000
Peru	Sep 2016	0.0010	72,250	4.744	1.148,375
Trinidad and Tobago	Sep 2013	0.0006	3,200	17.487	191,800
Uruguay	Jul 2014	0.0038	29,500	31.056	629,400
Venezuela, R.B.	—	0.0032	85,875	4.269	1.614,125

Notes: [a] indicates the annual average of R&D as a percentage of GDP (Million US$) based on panel from 2009 to 2018;

[b] refers to the average SCI publications by 100 mil habitants published by each country;

[c, d] refers to the average of the total of patents applied by (domestic and foreign) applicants in the national intellectual property offices of each country.

[e] refers to the month and year of acceptance on TRIPS Agreement.

4.2 Variables

4.2.1 Dependent variable

Dependent variable $R\&D_{i,t}$ measures the country's innovation performance, where *i* is the country, and *t* is the year. To measure the country's innovation performance in a given year, we adopted the total R&D expenditure (millions of US$) as a percentage of GDP (Wang, 2010; Castellacci & Natera, 2016). We choose this variable because R&D investments at the country level capture the technological development and the rate of technological progress (Stel et al., 2019). Moreover, the amount spent on R&D as a percentage of GDP seems to be directly related due to the greater patent protection (Varsakelis, 2001; Lall, 2003; Maskus et al., 2019). Finally, the ratio of R&D expenditure to GDP, commonly defined as the intensity of R&D investments, creates stronger incentives for R&D investments (Wang, 2010). Moreover, increases the patents obtained once this ratio is positively related to the strength of patent rights, the effective demand and the size of the market (Kim et al., 2012; Papageordiadis & Sharma, 2016).

4.2.2 Independent variables

To measure the innovation within a country, we adopted a proxy for innovation from domestic and foreign activities. The first is the *domestic innovation base index*. We follow the methodological approach suggested by Khoury and Peng (2011, p. 340) because we identified a high correlation between domestic and foreign patent applications (Cronbach's alpha > 0.9260). Moreover, our data suggests that the natural log of the number of patent applications from domestic owners and the natural log of scientific publications from within the country (by 100 mil habitants) are substantially collinear (see Table 4 and Table 4.1). To address this problem, Khoury and Peng' (2011) proposing the "Innovation base index", an index that offers a solution through the application of Principal Component Analysis (PCA). Similarly, we constructed this base index underlying the following individual items (the natural log of the number of domestic patent applications + the natural log of scientific publications). We performed a rotation (orthogonal varimax) of the loading matrix to obtain the "*domestic innovation base index*".

The second independent variable consists in the foreign innovation activity, constructed by two variables. We first selected the natural log of foreign patent applications in a given country. We adopted this proxy because high patent intensity from foreign applicants will indicate better intellectual property rights within the patent recipient country. We second chose the natural log of FDI inflows in a given country. The annual inflows of FDI capture the country's ability and source to attract capital, technology transfer, managerial and other skills (Smarzynska-Javorcik, 2004; Hudson & Minea, 2013; Lee et al., 2018; Viglioni & Calegario, 2020). Additionally, the FDI raises competition in domestic markets affecting domestic R&D investment decisions (Wang, 2010; Krammer, 2015). As noted on the number of domestic patent applications and the scientific publications, the natural log of foreign patent applications and the natural log of FDI inflows are highly correlated (Cronbach's alpha > 0.8962). For the same reason, we complement the past literature (Khoury & Peng, 2011), creating the "innovation base index" for foreign activities, but now considering the (ln FDI inflows + ln foreign patent applications). After this procedure, we built the "*foreign innovation base index*".

We chose the patent information in both indexes because it is increasingly being used as a measure of innovation (Hall & Maffioli, 2008). In fact, the use of patents is a kind of knowledge that is "above and beyond R&D inputs, a creation of an underlying knowledge stock" (Hall et al., 1986, p. 265). Different from R&D, patents are one formal registered source of rich innovation information on new technology (Nagaoka et al., 2010). However, we

restricted our analysis to the requested patents due to the bureaucracy levels across Latin countries[14] that produce negative externalities, such as the long time periods for granted patents to be recognized by the local administrative patent offices. Alternatively, we adopted the annually requested patents by domestic and foreign applicants within the country patent office in an equal attempt and a standardized measure of innovation effort to register new invents by both domestic and foreign parties.

Country Intellectual Property Right Protection Index

Our moderating variable is the Intellectual Property Right Protection Index – IPRPI, a composite index that measures the country's overall strength of legal protection environment. We constructed[15] an aggregating index based on North's (1990) theory considering six components from the "Institutional Pillar" extracted from the Global Competitiveness Report (GCR) to measure the strength of legal protection in each country. To construct the IPRPI, we adopted six components along a scale that ranges from 1 (worst) to 7 (best) to comprise the final index. The IPRPI is calculated for each country using the following components: (a) judicial independence; (b) efficiency of legal framework in challenging regulations; (c) efficiency of legal framework in settling disputes; (d) burden of government regulation; (e) property rights, and (f) intellectual property protection (for more detail of each component, see

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[14] This justification is backed by an ordinary issue reported in the 2016 "Special 301": Argentina — "There is a substantial backlog of patent applications which results in long delays in registering rights"; Costa Rica — "Pharmaceutical and agricultural chemical patent holders report various concerns, including as to Costa Rica's data exclusivity regime and extensive delays in regulatory approvals" and Brazil — "The United States also remains concerned that long delays in the examination of patents and trademarks persist with a reported pendency average of three years for trademarks and 11 years for patents." (USTR, 2016, pp. 49, 58, 61).

[15] One of the major motivations to create a new index is to overcome data availability problems to adopt the classical Ginart-Park Index (GPI) developed by Ginart and Park (1997) and further extended by Park (2008). Although the Ginart-Park Index is one of the most complete and adopted indexes by the empirical literature, "the GPI does not capture all the dimensions of IPRs and thus should be complemented with other measures when examining the IPR-innovation-growth relationship" (Neves et al., 2021, p. 200). Our index offers the advantage to consider a time-period after 2008. This is relevant once Latin economies changed several of their intellectual property rights policies after 2010 (e.g., post-TRIPS Agreement) and started to open their economies and to invest more in R&D activities.

the Appendix C in The Global Competitiveness Index Methodology and Technical Notes). For robustness, the extent of our index captures the classical property rights regulations (e.g., item e and f), which implicitly also captures the country's checks and balances (e.g., item a and b) in the burden of proof in process of infringement cases, and public-sector performance (e.g., item c and d) to bear the burden in a patent filling.

We selected these institutional indicators to construct the IPRPI because they are similar to the index of Strength of Legal Rights[16] developed by the World Development Indicator (for more detail, see Nuruzzaman et al., 2018). We submitted the six components to the PCA to create a unique IPRPI. Compounding them into an index is necessary because these six components are highly correlated and engender in multicollinearity (Cronbach's Alpha > 0.9147). Moreover, the use of this index as an interaction term allows us to determine if there is a significant relationship between strengthening IPRs protection and domestic and foreign innovation base activity within a country. Table 2 described the overall IPRPI estimates by each country of our sample.

Table 2 List of countries by IPRPI

Country	IPRPI	Country	IPRPI
Chile	2.4560	Mexico	0.3933
Uruguay	1.2773	Ecuador	0.3933
Costa Rica	1.2773	Guatemala	0.2459
Trinidad and Tobago	1.2999	Peru	0.0986
Panama	1.2999	Argentina	– 0.4907
Brazil	0.5406	Paraguay	– 0.6380
El Salvador	0.5406	Venezuela, R.B.	– 1.6694
Colombia	0.3933		

Note: The IPRPI refers to the highest value by each country based on the period of 2009–2018.

4.2.3 Control variables

We included a variety of control variables that can influence the country's innovation performance. First, we controlled for the country's trade openness because policies that strengthen intellectual property rights impact the extent of international trade in goods and services (Ginarte & Park, 1997; Maskus, 1998). We operationalized trade openness by (sum of exports and imports) over the country GDP to capture the potential for exchanging knowledge

[16] To overcome data availability problems, we do not adopt the "Strength of Legal Rights" index from WDI once the available data on WDI for Latin America and the Caribbean countries are available only after 2015.

and technical information with other nations, and thus, the capacity of imitating and absorbing foreign technologies (Varsakelis, 2001; Hudson & Minea, 2013; Sweet & Maggio, 2015; Papageordiadis & Sharma, 2016). Third, we controlled for a ratio of high-tech exports to capture some extent of technology sophistication (Papageordiadis & Sharma, 2016). Fourth, we controlled for a country's inflation GDP deflator to capture any macroeconomic instability that could depreciate the country's currency and thus affect the R&D investments.

Specifically, prior research established the influence of "Law on the books" and "Law in Practice" effects on domestic and foreign activities (Smarzynska-Javorcik, 2004; Papageordiadis et al., 2013), and we captured this influence by the two[17] IP variables. We first included the TRIPS membership, constructed as a dummy that reflects whether the country was officially accepted on post-TRIPS agreement or not (1 for the years following the country acceptance[18], and 0 otherwise). This variable captures the formal institution side, in other words, the "Law on the books". Second, we incorporated one proxy for the quality of "Law in practice" using the USTR "Special 301 report" measure as a standardization technique (z-scores) (see, Papageordiadis et al., 2013, p. 6). This variable captures the informal institutional effect of "law in practice" considering the USTR assigned changes and recommendations.

Finally, following the World Bank IBRD/IDA classification, we included a dummy variable equal 1 to control the group of high-income economies and a value of zero for the group of upper-middle- and low-income economies. We checked this dummy because R&D investment is closely related to high-income economies (Wang, 2010). Based on this principle, low- and middle-income countries usually are buyers of technology and at the very least, they fear that stronger protection at home would increase profit flows to foreigners (Athreye et al., 2020). A time dummy was included to control for other non-time-varying differences across countries. All variables, definitions, and data sources are summarized in Table 3.

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[17] Papageorgiadis and McDonald (2019) suggests considering two proxies for country IP protection systems approximating the different aspects of institutions connected to the effect of IP, one to capture the quality of "Law on the books" and for one for the quality of "Law in practice".

[18] Although many developing countries have ratified TRIPS, this does not indicate that these economies have strengthened their IPR institutions (Papageordiadis & McDonald, 2019). The signatory countries had considerable flexibility in implementing and enforcing standards, with a 10-year transition period, to gradually increase their IP protection standards (Lall, 2003; Brandl et al., 2019). For this reason, we considered only countries accepted on post-TRIPS.

Table 3 Variables, definition and sources

Dependent variable	Definition	Sources
$R\&D_{i,t}$	Country R&D expenditure as a % of GDP	RICYT www.ricyt.org
Independent variable		
Domestic patent applications	Natural logarithm of the number of requested patents by domestic inventors	RICYT www.ricyt.org
Scientific publications SCI	The natural logarithm of scientific publications from within the country (100 mil habitants)	RICYT www.ricyt.org
Domestic innovation base index	The host county's Innovation base index (see Khoury & Peng, 2011, p. 340)	
Foreign patent applications	Natural logarithm of the amount of requested patents by foreign inventors within the host country	RICYT www.ricyt.org
FDI inflows	Natural logarithm of net FDI inflows in US dollars	World Bank (WGI) www.worldbank.org
Foreign innovation base index	The base index is created using the PCA analysis between (ln FDI inflows + ln foreign patent applications)	
IPRPI	Constructing weighted aggregate country Institutional Pillar from the Global Competitiveness Report	World Economic Forum www.weforum.org
Control variables		
Trade	Ratio of exports and imports to GDP in US dollars	World Bank (WGI) www.worldbank.org
High-tech exports	High-technology exports in US dollars (% of manufactured exports)	World Bank (WGI) www.worldbank.org
Growth	GDP Growth rate %	World Bank (WGI) www.worldbank.org
"Special 301 report"	Measured based on the strength of border controls using the z-score standardization technique (see Papageordiadis et al., 2013, p. 6)	USTR http://www.ustr.gov
TRIPS	This is a dummy variable that assumes the value of 1 based on the year of acceptance on TRIPS agreement; 0 otherwise	World Trade Organization (WTO) www.wto.org
Income	High-income economies = 1; Upper-middle-and low-income economies = 0	World Bank IBRD/IDA[(a)] www.worldbank.org
Time dummy	Dummy variable used for years 2009–2018	—

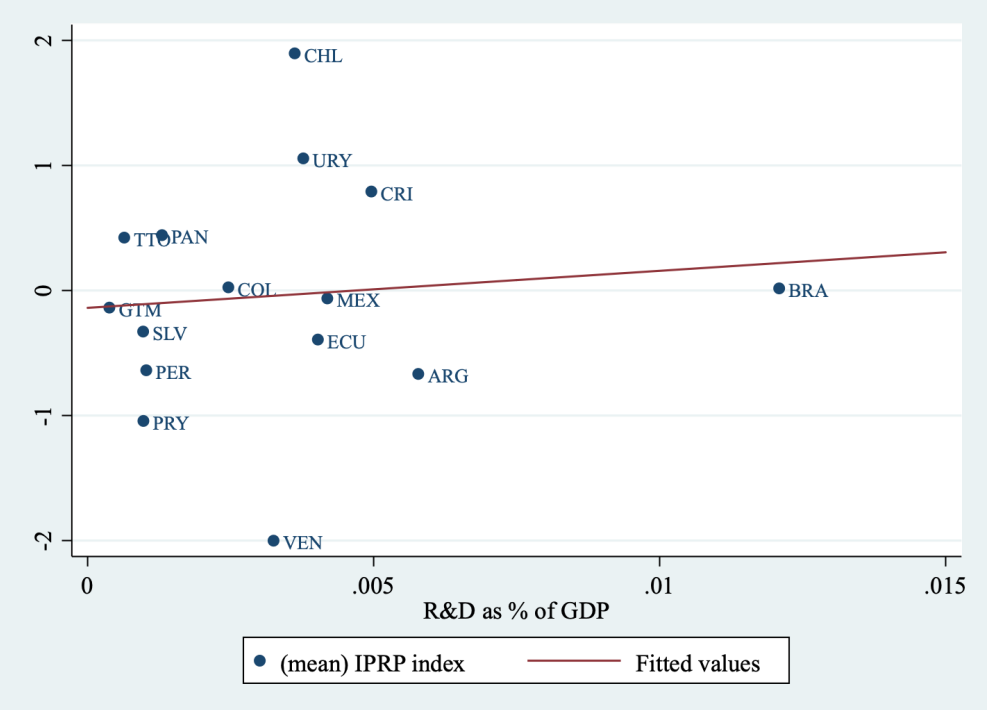
Notes: [(a)] The International Development Association (IDA) complements the International Bank for Reconstruction and Development (IBRD) from World Bank.

5. Descriptive statistics on IPRs protection and innovation in LAC countries

Overall, Figure 1 illustrates the scatter plot of IPRPI (y-axis) and the country's R&D (x-axis). The linear fit shows a positive relationship between both variables but reveals a disaggregated R&D intensity across countries. It is possible to observe that several Latin countries (e.g., Paraguay and Venezuela) experience negative dynamics in their intellectual property rights protection. Not surprisingly, poorer and less developed countries, such as Paraguay and Venezuela, shows considerable negative performance.

Overall, the linear fit is indicative of a strong positive relation between IPR and R&D as a percentage of GDP for countries above the fitted line. Conversely, the largest country from Latin America, Brazil, shows almost "the best of both worlds" combining an average IPRPI and R&D. This is an interesting result because the best-practice IPRPI countries (e.g., Costa Rica, Uruguay and Chile) do not necessarily showed a higher R&D intensity. In other words, it seems that Latin American countries that perform better on IPRs protection do not tend to invest more in R&D.

Figure 1 Intellectual Property Rights Protection – IPRPI and R&D

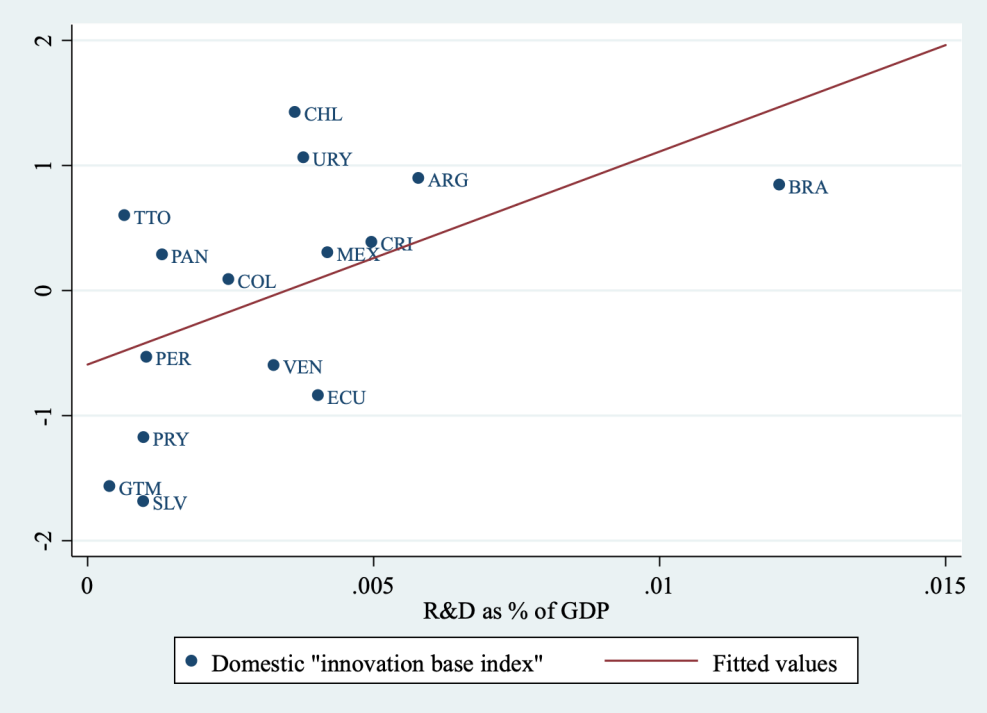


Note: Authors' calculations. This figure plots country's average IPRPI values against the country's R&D as a % of GDP. Legend: ARG = Argentina; BRA = Brazil; CHL = Chile; COL = Colombia; CRI = Costa Rica; ECU = Ecuador; SLV = El Salvador; GTM = Guatemala; MEX = Mexico; PAN = Panama; PRY = Paraguay; PER = Peru; TTO = Trinidad and Tobago; URY = Uruguay; VEN = Venezuela.

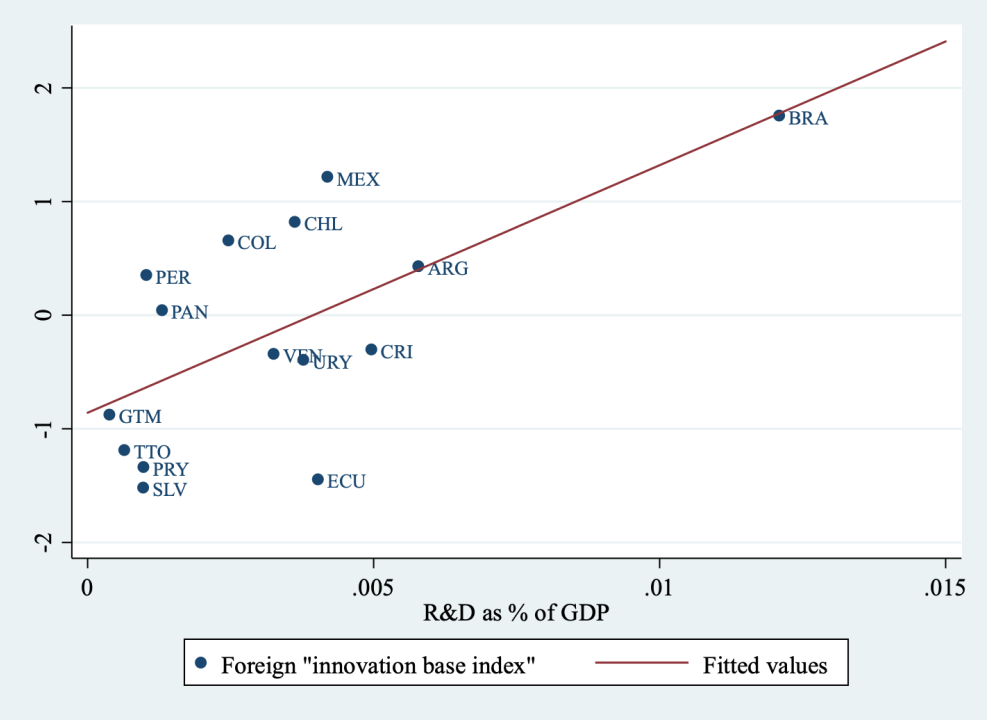
Interestingly, small economies, such as Trinidad and Tobago and Panama, reveal an IPRPI score above several other Latin economies. This finding illustrates the considerable relevance for future research in understanding why small economies, regarding Central America (Caribbean Community), show significant improvements in their IP systems. Other economies, such as Guatemala, Colombia and Mexico, showed a more fitted value.

Figure 2 (a-b) displays the scatter plot between domestic (a) and foreign (b) innovation base index and the country R&D (as a % of GDP). The linear fit in both panels (a-b) shows a strong and positive relationship between domestic and foreign innovation base index and the country's R&D. Notwithstanding, the finding should be interpreted carefully once different patterns are observed by both country's R&D and the domestic and foreign innovation activity. Panel (b) plots a more well-fitted value. In other words, LAC countries show their real differences in their domestic innovation activities, while the foreign innovation activity is more homogeneous across the sample.

Figure 2 (a-b) Domestic and foreign "innovation base index" and country's R&D



(a)



(b)

Note: Authors' calculations. This figure ploys country's average domestic (a) and foreign (b) innovation base index against the country's R&D as a % of GDP. Legend: ARG = Argentina; BRA = Brazil; CHL = Chile; COL = Colombia; CRI = Costa Rica; ECU = Ecuador; SLV = El Salvador; GTM = Guatemala; MEX = Mexico; PAN = Panama; PRY = Paraguay; PER = Peru; TTO = Trinidad and Tobago; URY = Uruguay; VEM = Venezuela.

Moreover, it is possible to observe on both panels (a-b), some countries (e.g., TTO – Trinidad and Tobago) perform better on domestic innovation activities but, at the same time, show lower foreign innovation activity in the presence of positive IPRPI, as reflected in Figure 1. Thus, the Latin American and the Caribbean countries that perform better on IPR protection (with exceptions) do not necessarily tend to achieve higher foreign innovative activities. All in all, Latin American countries with large R&D expenditures as a percentage of GDP tend to have a higher presence of foreign innovation than domestic ones.

6. Estimation methods

In order to examine the country's innovation performance, the following basic model was devised as Equation (1) shows. The dependent variable represents the innovation performance denoted by ($R\&D_{i,t}$) at country i and time t. The independent variables are the domestic innovation base index indicated by (*Domestic innovation*) and the foreign innovation

base index (*Foreign innovation*). The intellectual property rights protection index is denoted by (*IPRPI*), followed by their respective squared term ($IPRPI^2$) in order to capture for nonlinearities. The control variables are indicated by trade openness (*Trade*), high-tech exports (*Tech Exports*) and a dummy for TRIPS agreement (*TRIPS*) and the USTR "Special 301 report" (*USTR Special 301*), country income (*Income*) and time dummies γ to capture any differences that could appear across the years. The u_{it} are the residuals.

$$\begin{aligned} R\&D_{i,t} = {} & \alpha_i + \beta_1 Domestic\ \ innovation_{\ i,t} + \beta_2\ Foreign\ innovation_{i,t} \\ & + \beta_3 IPRPI_{i,t} + \beta_4 IPRPI^{\,2}{}_{i,t} \\ & + \beta_5 (Domestic\ \ innovation_{i,t} \times IPRPI_{i,t}) \\ & + \beta_6 \left(Foreign\ innovation_{i,t} \times IPRPI_{i,t}\right) + \beta_7 Trade_{i,t} \\ & + \beta_8 Tech\ Exports_{i,t} + \beta_9 TRIPS_i + \beta_{10} USTR_i + Income_i + \gamma_t + u_{i,t} \end{aligned} \quad (1)$$

One concern is that some variables are likely to be predetermined with others (e.g., domestic and foreign innovation, FDI and Growth, and others), implying endogeneity. Khoury and Peng (2011) adopted the OLS method with panel-corrected standard errors. Nonetheless, and considering the endogeneity circumstances, we adopted the Random-effects Generalized Least Squares (GLS) and subsequentially the Two-Stage Least Squares (2SLS) with instrumental variables (IV) estimators increasing the robustness of results. We choose the GLS and 2SLS (IV) estimators after considering that the basic model does not show any heteroskedasticity and autocorrelation problem. In other words, a Generalized Least Squares (GLS) estimator, such as the Generalized Method of Moments (GMM), is a common approach in case of heteroscedasticity and serial correlation, but that would not fit properly in our model.

To avoid endogeneity, the dependent variable is one year ahead and all control variables are lagged in one year (t-1). To check the endogeneity, we performed specific tests to determine whether variables are strictly endogenous. Further, we checked the first stage regression statistics to measure the relevance of the excluded exogenous variables. Specifically, we perform the test of overidentifying restrictions of instruments to check their validity. In this case, the Sargan (1958) and Basmann (1960) chi-squared tests are jointly verified.

7. Results

Table 4 shows that the correlation is close to 0.80 and, in some cases, trespass the 0.90 value (ln Foreign patents and ln Domestic patents). As we have previously shown in the methodology, it was mandatory to rule out multicollinearity in our model. In this case, we developed the innovation base index. Other variables also show a high correlation (ln FDI and ln Foreign patents) due to their foreign similarities. Using the same strategy, we developed the foreign innovation base index. To avoid doubts about multicollinearity, it is worth considering the variance inflation factor (VIF). As expected, the VIF values are high and near the limit of 10 (see Table 4).

We provided a second correlation matrix (see Table 4.1). It is possible to observe that the correlations dramatically decrease the chance of multicollinearity in our model when we generate the domestic and foreign innovation indexes. For consistency, the VIF test reports the variance score for all variables in Table 4.1, indicating that our estimates are not significantly biased by multicollinearity and should not affect our results. The highest VIF value and the estimated average obtained were 2.74 and 1.70, respectively. As recommended by Hair et al. (2010), all values are far below the threshold limit of 10. Moreover, it is necessary to mention that, in the first moment, we have an additional concern with the mean and standard deviation variability, which could raise questions about our descriptive statistics. Nonetheless, for example, our domestic innovation index is in line with the estimated values by Khoury and Peng (2011).

Table 4 Descriptive statistic and correlation

Variables	Mean	S.D	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	VIF
(1) R&D	0.0034	0.0029	1.000										—
(2) ln Domestic patents	4.4357	2.1472	0.725***	1.000									11.00
(3) ln SCI publications	2.1441	1.1874	0.556***	0.527***	1.000								2.92
(4) ln Foreign patents	7.0852	1.4523	0.735***	0.926***	0.509***	1.000							9.46
(5) ln FDI	15.2603	1.6142	0.624***	0.855***	0.674***	0.863***	1.000						7.13
(6) IPRPI	2.70E-09	1.0000	0.085	0.025	0.503***	–0.014	0.234***	1.000					1.90
(7) Trade	0.5763	0.2299	–0.516***	–0.535***	–0.168*	–0.553***	–0.373***	0.273***	1.000				2.00
(8) Tech exports	10.8389	8.9318	0.328***	0.121	0.207**	0.206**	0.188**	0.187**	0.201**	1.000			1.28
(9) Growth	2.7329	2.9782	–0.195**	–0.153*	–0.088	–0.155*	–0.024	0.186**	0.265***	0.032	1.000		1.41
(10) USTR Special 301	0.0555	0.9949	0.088	0.009	–0.092	0.000†	0.070	–0.011	–0.114	0.074	0.007	1.000	1.23

Note: Level of significance: * < 0.10, ** < 0.05, *** < 0.01; † = 1E–05

Table 4.1 Descriptive statistic and correlation after Principal Component Analysis

Variables	Mean	S.D	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	VIF
(1) R&D	0.0034	0.0029	1.000								—
(2) Domestic innovation	9.75E-10	1.0000	0.556***	1.000							2.74
(4) Foreign Innovation	1.73E-09	1.0000	0.624***	0.674***	1.000						2.23
(6) IPRPI	2.70E-09	1.0000	0.085	0.503***	0.234***	1.000					1.67
(5) Trade	0.5763	0.2299	–0.516***	–0.168*	–0.373***	0.273***	1.000				1.75
(6) Tech Exports	10.8389	8.9318	0.328***	0.207**	0.188**	0.187**	0.201**	1.000			1.22
(7) Growth	2.7329	2.9782	–0.195**	–0.088	–0.024	0.186**	0.265***	0.032	1.000		1.16
(8) USTR Special 301	0.0555	0.9949	0.088	–0.092	0.070	–0.011	–0.114	0.074	0.007	1.000	1.13

Note: Level of significance: * < 0.10, ** < 0.05, *** < 0.01.

Table 5 presents the results for the Random-effect GLS and 2SLS (IV) regression. Additionally, all 2SLS estimations individually passed in all test specifications (see Table 6). Model 1 tests all control variables and it is possible to observe from Model 1 to Model 10 a consistent R^2. Model 1–6 test indicates all GLS estimations and further, Model 7–10 tests all the 2SLS. Model 2 tests the domestic innovation activity and shows positive and high significance ($p < 0.01$). Overall, the results support Hypothesis 1 and the idea that the greater the domestic innovative activity (*ceteris paribus*), the higher the innovation performance within the country. This result is essential for Latin American and the Caribbean countries and advances studies that the domestic innovation base activity impacts the country's R&D performance. At the same time, this finding also contradicts the literature that developing economies do not have enough innovation activity.

Our result indicates that IPRPI and the squared term do not have an impact on domestic innovation activity. However, considering the interaction term, Model 3, it is possible to observe that IPRs protection shows positive results over the domestic innovation activity and the country's R&D performance. We identified that, to some extent, IPRPI positively contributes to domestic innovation activity. Nonetheless, we cannot infer about the squared term. Similarly, Model 4 reveals that foreign innovation activity shows positive results to the country's R&D performance, supporting Hypothesis 2a and the idea that the greater the foreign innovative activity in the host country (*ceteris paribus*), the higher the innovation performance in a given country. Both domestic and foreign innovation activity results in positive gains, albeit domestic innovation shows higher coefficients. Model 5 tests the interaction effect between (foreign innovation performance × IPRPI). The results are similar to domestic innovation, in which foreign activity shows positive in the presence of a strong IPRs protection. Again, it is not possible to infer about the squared term.

Table 5 Random-effect GLS and 2SLS (IV) regression results

	Random-effect GLS regression						2SLS (IV) regression			
Dependent variable (One year ahead)	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Domestic innovation		0.0017***	0.0019***			0.0016***	0.0028***	0.0039***		
		(0.0003)	(0.0003)			(0.0010)	(0.0004)	(0.0006)		
Foreign innovation				0.0001***	0.0013***	0.0003			0.0016***	0.0019***
				(0.0002)	(0.0004)	(0.0003)			(0.0003)	(0.0004)
IPRPI		–0.0004	–0.0008	–0.0002	8.3E-05	–0.0006	–0.0009**	–0.0012**	–0.0005	9.9E-05
		(0.0004)	(0.0005)	(0.0004)	(0.0005)	(0.0004)	(0.0004)	(0.0006)	(0.0004)	(0.0004)
IPRPI Squared		–8.2E-05	–0.0008*	–5.2E-05	–6.2E-05	–4.7E-05	–0.0002	–0.0008*	–0.0001	0.0001
		(0.0002)	(0.0005)	(0.0002)	(0.0004)	(0.0002)	(0.0002)	(0.0005)	(0.0002)	(0.0003)
Domestic innovation × IPRPI			0.0012**					0.0020***		
			(0.0005)					(0.0006)		
Domestic innovation × IPRPI Squared			0.0003					–0.0001		
			(0.0004)					(0.0004)		
Foreign innovation × IPRPI					0.0006*					0.0006**
					(0.0003)					(0.0003)
Foreign innovation × IPRPI Squared					–0.0004					–0.0007**
					(0.0003)					(0.0003)
Trade	–0.0078***	–0.0058***	–0.0061***	–0.0061***	–0.0061***	–0.0052***	–0.0043***	–0.0041***	–0.0049***	–0.0050***
	(0.0010)	(0.0010)	(0.0010)	(0.0012)	(0.0012)	(0.0012)	(0.0011)	(0.0012)	(0.0012)	(0.0012)
Tech exports	0.0001***	0.0001**	7.6E-05***	9.53E-05***	9.1E-05***	6.6E-05**	4.5E-05*	3.3E-05	9.2E-05***	7.9E-05***
	(2.6E-05)	(2.6E-05)	(2.8E-05)	(2.9E-05)	(3.1E-05)	(2.8E-05)	(2.6E-05)	(3.1E-05)	(2.7E-05)	(2.8E-05)
Growth	–7.0E-05	–3.8E-05	–1.6E-05	–5E-05	–9.1E-05	–3.8E-05	–9.49E-06	–2.3E-05	–4.5E-05	–0.0001
	(1.03E-04)	(9.3E-05)	(9.5E-05)	(0.0001)	(0.0001)	(9.7E-05)	(0.0001)	(9.9E-05)	(9.6E-05)	(9.6E-05)
USTR Special 301	–5.4E-05	0.0002	0.0001	–1.3E-05	4.54E-06	0.0003	0.0004**	0.0005**	4.1E-05	0.0001
	(2.27E-04)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0002)
TRIPS	0.0018***	0.0006	0.0005	0.0010*	0.0008	0.0003	–0.0003	–0.001	0.0004	0.0004
	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0006)	(0.0006)	(0.0005)	(0.0006)	(0.0005)	(0.0006)
Income	0.0007	–0.0010	–0.0025**	0.0008	0.0005	–0.0007	–0.0017*	–0.0048***	0.0012	0.0005
	(0.0006)	(0.0009)	(0.0016)	(0.0011)	(0.001)	(0.0011)	(0.0010)	(0.0014)	(0.0010)	(0.0010)
Constant	0.0050***	0.0066***	0.0069***	0.0059***	0.0060***	0.0065***	0.0067***	0.0081***	0.0059***	0.0060***
	(0.0010)	(0.0007)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0008)	(0.0010)	(0.0009)	(0.0009)
Time-year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	116	115	115	110	110	110	115	110	110	110
R^2	0.5192	0.6281	0.6478	0.5793	0.5972	0.6310	0.5730	0.5676	0.5598	0.5832
Wald chi2 Prob > chi2	107.970***	162.130***	172.866***	125.293***	131.951***	153.872***	183.645***	177.580***	158.190***	166.930***

Notes: All standard errors in parentheses. Level of significance: * < 0.10, ** < 0.05, *** < 0.01. The dependent variable is the country's R&D as a % of GDP (one year ahead). All control variables are lagged in one-year.

Considering the 2SLS estimator, the results remain quantitatively similar to those presented for the GLS regressions, but, at the same time, with more robustness due to the addition of instruments (IV) to control endogeneity (see Table 6). In Model 7, it is possible to note that the IPRPI negatively impacted the country's innovation performance. Overall, this may be related to the fact that not all Latin American economies have a sufficient innovative capacity to hold an IPRs policy. For example, several economies are very poor, with insufficient domestic innovation activity, while others already have more developed innovation base activities. Model 8 reveals important inform, albeit the squared term showed low statistical significance ($p < 0.10$). The interaction term between (domestic innovation × IPRPI) is positive and highly significant ($\beta = 0.0020$, $p < 0.01$), whereas the squared term does not reveal any statistical significance. Our results suggest preliminary nonlinearities. We conducted additional tests to capture the true nonlinearity effect (the nonlinearity test is presented and detailed in Table 7), which reveals a U-shaped pattern, supporting Hypothesis 1b.

Model 9 shows similar (but more robust results) for the foreign innovation activity. Our empirical analysis does not offer unconditional support for Hypothesis 2c. This is because, different from what we expected, both domestic ($\beta = 0.0028$, $p < 0.01$) and foreign innovation activity ($\beta = 0.0016$, $p < 0.01$) showed positive and high statistical results. Nonetheless and surprisingly, it seems that domestic innovation shows a higher innovation activity than foreign ones. Overall, this finding contributes with theoretical implications, indicating that domestic innovation activity in developing economies shows positive results in the presence of IPRs. Another finding comes from Model 10, where both linear and the squared term showed statistical significance ($p < 0.05$). In the first moment, we have a positive and significant coefficient ($\beta = 0.0006$, $p < 0.01$) from the interaction between (foreign innovation × IPRPI). Nonetheless, the squared form shows a negative and significant effect ($\beta = –0.0007$, $p < 0.01$). This negative association is an indication that, to some extent, an unbridled IPRs protection policy could harm foreign innovation activity. Moreover, this result also suggests an inverted U-shaped relationship, supporting Hypothesis 2c (see Table 7).

Looking at the control variables, trade openness showed negative and high significance across all models. This may be possible due to the country's trade and balance, where some countries import more than export or export low-value goods. Nonetheless, the export of technology shows a positive coefficient, implicating that the export of technology is necessary to increase the country's innovation performance. It is important to observe that the controls for "Law on the books" by TRIPS and "Law in practice" by USTR Special 301 almost do not show significance across the estimated models. Nonetheless, it seems that the USTR Special

301 may show large implications for the country's innovation performance (Model 7 and 8). This observation leads us to discuss that the restrictions imposed on countries that do not act according to the IPR's best practices are more efficient that "Law on the books", such as the TRIPS agreement.

To test the endogeneity of the instrumental variables, the Durbin and Wu-Hausman F were applied. The null hypothesis informs that variables are exogenous and we could use the regular GLS instead of the 2SLS (IV). Nonetheless, the Durbin's and Wu-Hausman's indicate high statistical significance and the independent variable is correcting treating as an endogenous variable. To check the strength of instruments, the R^2 and adjusted-R^2 statistics showed that the correlation between the independent variable and the instruments implies strong instruments. Alternatively, the F statistics for the joint significance are large (above the threshold of 10). Additionally, the F statistics are significant in all regressions, indicating the additional instruments have high significant explanatory power.

Table 6 Statistics test for 2SLS (IV) regression

	Model 7	Model 8	Model 9	Model 10
Tests of endogeneity				
Durbin (score) chi2(1)	17.6303***	18.8157***	17.8504***	9.94193**
Wu-Hausman F	17.2012***	18.1586***	17.4340***	8.74382***
First-stage regression				
R-sq. (Adjusted-R-sq.)	0.81(0.78)	0.86(0.82)	0.88(0.86)	0.90(0.88)
F statistic Prob > F	F(2,95)***	F(2,88)***	F(2,90)***	F(2,88)***
	49.3826	33.8996	157.8670	114.3710
2SLS relative bias†	13.91	13.91	13.91	13.91
2SLS Size of nominal 5% Wald test	19.93	19.93	19.93	19.93
Tests of overidentifying restrictions				
Sargan (score) chi2(1)	0.781651	3.89742**	4.93627**	0.655695
Basmann chi2(1)	0.650131	3.23246*	4.22852**	0.527701

Notes: Level of significance: * < 0.10, ** < 0.05, *** < 0.01. The 2 SLS regression with 3 endogenous 2SLS relative bias (5%) is provided by Stock and Yogo's (2005) critical values. † The 2SLS relative bias and 2SLS Size of nominal 5% Wald test follow a rejection rate of 10%.

Observing the critical values for the 2SLS and considering a Stock and Yogo's (2005) critical values rejection rate of 5% for 2SLS relative bias and a tolerance rejection of 10% for 2SLS nominal 5% Wald test, we reject the null hypothesis that the instruments are weak because all the F statistics exceeded the critical values for both cases (2SLS relative bias and 2SLS Size of nominal). Finally, Sargan and Basmann's chi-squared reports all overidentification statistics. All tests indicated that, at 1 % of significance, the joint null

hypothesis is valid for the excluded instruments and each specified model. The only exception is Model 8 and Model 9, indicating possible weak evidence (at the 5% level). Nonetheless, this does not bring in bias any to our analysis (at the 1% level).

Additional analysis was performed to prove the existence of a U-shaped (or inverted U-shaped) relationship applying the *utest* (Lind & Mehlum, 2010), as Table 7 indicates. Consistently, the diagnostic test is connected to the nonlinear assumptions provided by Table 6. The test is necessary because the squared term that has opposite signs is generally weak and insufficient to prove the existence of a U-shaped or inverted U-shaped relationship (Lind & Mehlum, 2010). The null hypothesis of either a monotone or direct U-shape relationship supports domestic innovation analysis ($p = 0.103$). The test validates the U-shape relationship, providing additional support for Hypothesis 1b.

Furthermore, in this case, the vertex of the parabola lies between the interval (–2.4061 to 2.4560). The confidence interval for the estimated extreme value achieves its peak when the IPRPI hits the extreme point (–0.7530). This means that, as IPRs protection increases in a given country, the domestic innovation activity decreases near this limit. In other words, in the presence of strong IPRs protection, the domestic innovation activity is overwhelmed. For instance, Furukawa (2010) argues that this is possible because high costs of innovation, both very weak and strong IP systems, lead to lower innovation.

Table 7 Test monotonic curve – *Utest*

	Domestic innovation		Foreign innovation	
	Lower bound	Upper bound	Lower bound	Upper bound
Interval	–2.4061	2.4560	–2.4061	2.4560
Slope	0.0027	–0.0052	0.0004	0.0006
t-value	1.2734	–1.9771	–0.2346	0.3379
p-value	0.1027	0.0252	0.4074	0.3680
Extreme point	–0.7530		–0.4635	
Presence of U shape	H0: Monotone or U-shape H1: Inverse U-shape		H0: Monotone or Inverse U shape H1: U-shape	
t-value statistic (P>|t|)	1.27 (0.103)		0.23 (0.407)	

Notes: p-value in parenthesis. Level of significance: * < 0.10, ** < 0.05, *** < 0.01. The *utest* is based on the 2SLS regression results (Model 8 and 10, respectively).

As mentioned earlier, although the domestic innovation ($\beta = 0.0028$, Model 7) shows a higher coefficient than foreign activity ($\beta = 0.0016$, Model 9), in the presence of strong IPRPI

(Model 8), the country's innovation performance seems to be negatively affected. The U-shaped greatly indicates this result; that is, the domestic innovation holds their laggard status of economies that copy innovations. This finding is consistent with previous literature suggesting that several developing economies may not have enough knowledge structure and absorptive capacity to change this situation (Sweet & Maggio, 2015; Stel et al., 2019). In line with Hudson and Minea (2013), we suggest that a strong IPRs protection policy may simply harm the preferable choice to copy and imitate.

This result highlight two major policy implications. First, policymakers need to set up their institutions, strengthen their country's IPRs protection and monitor such evolution with caution. Second, this result is an important step towards investing in R&D, and policymakers need to wisely intermediate and implement such investments as the country's IPRs protection increases. As the U-shaped pattern reveals, it is necessary to invest in R&D with IPRs protection policy aligned to break the status of laggard economies and achieve higher innovative performance.

Nonetheless, the opposite is observed for the foreign innovation activity. The foreign innovation activity supports the null hypothesis of the inverted U-shape relationship (p = 0.407), providing support for Hypothesis 2b. Finally, it is possible to observe an inverse U-shape pattern for the foreign innovation when IPRPI hits the extreme point (–0.4635) between the interval (–2.4061 to 2.4560). In line with Lee et al. (2018), it is possible to conclude that as the IPRs protection is strengthened, foreign innovation performance is challenged to increase. Taking in other perspectives and to some extent, strong IPRs protection enhances the foreign innovation activities and the innovation performance in a given country.

8 Discussion of results

8.1 R&D implications for Latin America and Caribbean countries

In summary, our empirical analysis contributes to the innovation literature offering relevant new R&D implications and insights for Latin America and Caribbean countries. First, in the case of macro-level studies, there is a relatively high number of researches considering the domestic innovation activity and a low number considering the effect of foreign activity. Advancing, we developed a research to understand the IPRs effects on both domestic and foreign innovation activities in a given country.

Second, the estimations showed that domestic innovation positively contributes to the country's innovation performance. Although this is intuitive, there are caveats. In particular,

Latin American countries need to improve domestic innovative activities. This is because the level of knowledge and innovation may not be sufficient to hold increases in IPRs protection policy (Sweet & Maggio, 2015). While we accepted Hypothesis 1, we suggested that countries have low domestic innovation activity and may lack an efficient absorptive capacity to sustain innovative activities in higher IPRs environments. In other words, domestic innovation activities are generally underprepared to face a high IPR policy. That implies why it was observed a U-shaped relationship.

Third, variations on IPRs protection by policymakers must follow the domestic innovation activity. Nonetheless and similar to Hudson and Minea (2013), our findings show how complex is to increase the country's IPRs. In our understanding, there are alternative solutions to increase the domestic innovation base. For instance, a country with a greater foreign presence tends to have stronger IPRs, stimulating local investments in R&D (Lee et al., 2018; Maskus et al., 2019).

On the other hand, this makes the situation rather complex. This is because increases in the IPRs to attract more foreign capital may negatively affect the transfer of knowledge and local innovation (Stel et al., 2019). We need to look forward to develop complementarities to foreign capital and, at the same time, benefit from increasingly advances in IPRs protection. For example, Varsakelis (2006) and Coe et al. (2009) explains that investments in quality education systems increases the local innovation output activities. Put in other words, the intent of government facilitating quality education is one of the goals to reach high R&D expenditure in a given country. This may also strongly help developing economies to increase their domestic innovation activity and, at the same time, cautiously dose the IPRs protection to increase their innovation performance without losing the benefits from the foreign presence.

8.2 IPRs protection and policy implications

Accounting for the IPRs protection, our study reveals valuable policy implications for Latin economies. First, considering the nonlinearities, policymakers must decide and control their IPRs in a given country with caution. For instance, countries with high IPRs not necessarily will show higher domestic innovation. This insight is divergent from previous literature (e.g., Varsakelis, 2009) and the idea that the stronger the country's IPRs, the higher the R&D investment intensity. More specifically, our findings are unambiguous with the contemporaneous literature (e.g., Sweet & Maggio, 2015; Stel et al., 2019), suggesting that

stronger IPRs systems engender higher levels of economic complexity and hamper knowledge diffusion.

Second, our results contributed to the IPRs literature. The modern literature is concerned about the real benefits to skyrocket the country's IPRs protection. In this case, there is a long-standing debate related to the weight of increasing the IPRs to foster innovation development and knowledge flows across economies. For instance, lawmakers should think twice before creating a more rigorous IPR policy. At the same time, policymakers should tread lightly and use our insight to analyze and implement a "moderate" IPR protection to benefit both domestic and foreign innovation base activity (Furukawa, 2010; Liu & Li, 2019). In terms of policy implications, the equilibrium is desirable because there is no doubt that foreign investors in technology-intensive sectors heavily rely on IPRs (Smarzynska-Javorcik, 2004; Maskus et al., 2019). Therefore, undermining the patent system may severely injure future innovation.

Our major concern for policymakers does not lie in the commitment to strengthening the country's IPRs protection. Differently, they must be aware to find the perfect balance between positive and negative externalities of the IPRs institution. On the one hand, policymakers need to set up and develop domestic innovation activities. On the other hand, they must continue attracting and developing foreign innovation activities in a given country, which is also a source of innovation spillover for domestic innovative activities. Now more than ever, we recognize these lessons are challenging for developing economies, albeit necessary for a globalized economy moved by knowledge. Nonetheless, this "moderate" IPRs effect is challenging for policymakers. Accordingly, we suggest more research investigating the IPRs balance in developing economies.

Third, since the North's (1990) work, the institutional theory has become recursive to explain the performance in developed and developing economies. Nonetheless, the number of studies controlling specific formal and informal institutional parameters remains relatively scarce. We provided evidence of important and under-researched institutional standards, the "Law on the books" using the TRIPS agreement and "Law in practice" considering the USTR Special 301 (Smarzynska-Javorcik, 2004; Papageorgiadis & McDonald, 2019). Nevertheless, we do not observe a dramatic implication from those institutions. Based on our analysis, it seems reasonable to argue that the USTR Special 301 implicates positive benefits to the country's innovation performance. To our knowledge, more research will be required considering the TRIPS agreement and the USTR Special 301 to account for their effects across countries and firms.

9 Limitations and future research

While our findings are informative, this study is not free of limitations. First, we provided a methodological contribution by developing a unique index considering the "Institutional Pillar" from the GCR. We believe that this methodology could be applied in future research, at the country- and firm-level analysis. Although, our IPRPI may fall in minimalism and may weak to capture all the country IPRs protection. In this case, there are other IPRs indexes that are complete and more accurate (e.g., Park, 2008; Papageorgiadis et al., 2013; Papageorgiadis & Sofka, 2020). Considering our data limitation, future research should account for these approaches to enrich the innovation and IPRs studies in Latin America.

Second, once we adopted country-level data, we suggest that future research should adopt a firm-level analysis. In sum, we need to know more about the role of IPRs protection and firm innovation performance in developing economies. Nonetheless, for example, firm-level patent data is undeniably scarce in Latin America. As researchers, we know how difficult it is to forfeit a challenge. Therefore, we strongly recommend that future research to advance this subject with new theoretical contributions and policy implications.

10 Conclusions

This study examined how the role of country intellectual property rights protection affects innovation performance across several Latin American and the Caribbean countries. Addressing the country's institutional economics and drawing from a 9-year panel with 15 Latin American and Caribbean economies, we developed a unique IPRPI to assess the distinct impact on domestic and foreign innovation base activities and their causal relationship in the country's innovation performance.

We first observed that domestic innovation activity shows positive results, especially when it interacted with the country's IPRs protection. The same was observed for the foreign innovation activity, which shows positive results. Considering the interaction term, the foreign innovation activities showed positive results in the presence of the country IPRs protection. By contrast and interestingly, we observed the opposite for the squared term. This result was striking and bear important policy implications for economies that aim for an unbridled IPRs policy.

Specifically, the nonlinear refashioning brings striking theoretical and policy contributions. First, we observed a U-shaped relationship for the domestic innovation activity,

which means strengthening the IPRs protection could overload domestic innovation. In this case, it is necessary to develop R&D policy implications to foster domestic innovation and, at the same time, strengthen the IPRs protection with caution. On the other hand, for the foreign innovation activity the opposite was observed. Although we identified an inverted U-shaped pattern, strengthening too much the country's IPR protection may bring negative consequences for foreign innovation activity.

Based on these results, policymakers need to be aware of the responsibilities to focus on strengthening the country's IPRs protection. To some extent, increasing IPRs should not remain an issue at all. Nonetheless, it seems tremendously important to understand that unbridled IPRs protection in developing economies may be onerous for domestic base innovation. Thereby, the balance seems preferable. Put in another way, perhaps a more "moderate" approach seems preferable than an unbearable high IPRs protection policy. In conclusion, regarding the protection of IPRs and to keep making progress with the creation and diffusion of technology in developing economies, it is worthwhile to invite future research to think more about the following quote: "As long as technologies are not something to be locked away in a safe – otherwise they become obsolete – IP protection will always be the result of a delicate and dynamic balance" (Zhao, 2020, pp. 73-74).

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ARTICLE 3 – R&D INVESTMENTS, FIRM PERFORMANCE AND THE ROLE OF COUNTRY INSTITUTIONS: EVIDENCE FROM LATIN AMERICA

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R&D Investments, Firm Performance and the Role of Country Institutions: Evidence from Latin America

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Abstract

Drawing on institutional economics this paper investigates how the firm's R&D performance is moderated by the relationship between R&D investments and the role of country institutions. Using comprehensive panel data for Latin American firms, our empirical exercise supports the theoretical predictions that "institutions matter" for the firm's R&D investments. While empirical finding suggests that a firm's R&D investments hold a positive short-term performance, the opposite is observed for the long-term orientation. The analysis offers implications for policymakers and managers to respectively improve the country's institutions and safely double down the sheer amount of R&D aiming at the long-term firm's performance.

Keywords: R&D investments; Firm performance, Institutional environment; Developing economies; Latin America.

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1. Introduction

"*Mary had a little lamb*" – was a famous recital recorded in 1877 by Thomas Alva Edison[19] in his marvelous and historical technology – the Phonograph. It is impressive, if not unbelievable, how inventors' efforts, as well as Edison's unbreakable determination, resulted in a giant step towards the world's most innovative companies, such as Apple, Samsung, Google, Amazon, Micron Technology Inc., TSMC and Tesla. Behind these and other indistinguishable companies, innovation – that is, R&D is a fully acknowledged activity that enables firms to sufficiently explore and generate scientific knowledge (Griliches, 1979). Now more than ever, researches emphasized how the firm's R&D investment is essential for initiating innovative projects (Un and Montoro-Sánchez, 2011) to achieve higher and long-term performance (Alam et al., 2019a; Alam et al., 2020; Pindado et al., 2015) and to foster wealth and growth in all economies (Andrés and Min, 2020; Seitz and Watzinger, 2017).

Nevertheless, and by their very nature, R&D is expensive, uncertain, and inherently risky (Bianchini et al., 2019; Hillier et al., 2011; Iturriaga and López-Millán, 2017). Naturally, R&D could be even more challenging for developing economies. This is because developing economies are deeply characterized by assorted institutional issues (Peng et al., 2008). Acknowledging the role of institutions, empirical studies conspicuously proclaim in the direction that "institutions matter" as an economic instrument to foster innovative activities and guarantee long-term growth (Acemoglu and Robinson, 2008; Acemoglu et al., 2019; Meyer et al., 2009). For instance, there is considerable evidence that institutions provide subsidies (Sun et al., 2018), facilitate the creation of local R&D networks and spillovers (Mahmood and Rufin, 2005), and, therefore, provides what firms cannot produce individually (Wu et al., 2016). However, it seems very reasonable to argue that in the presence of an institutionally underdeveloped environment or even risky, neither R&D investments nor a firm's performance might be well succeeded.

Despite the significant effort that prior literature has made to understand how institutions affect the firm's performance in developing economies (e.g., Alam et al., 2019a; Barasa et al., 2017), we still know relatively little about the institutional shadows that are surrounding the firm's R&D investments in Latin American economies. To push the analysis into an under-researched region, we explore how the firm's R&D performance is moderated by

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the relationship between R&D investments and the role of country institutions in Latin America – Brazil, Chile, Mexico, and Peru. Drawing on the institutional economics (North, 1990; 1991), we conservatively propose that the role of a country's institutions is deep-seated on social or legal acts, property, wealth, the State's concept, and their efficiency, cultural prescriptions, ethics and the rights that regulate society's functioning. We argue these concepts are not entirely isolated, and, at the very least, may straight affect the firms to conduct R&D investments in the short- and long-term. In addition, considering the role of institutions is fundamentally necessary once an institutional system will be complete only when both formal and informal institutions were taken into account (Dunning and Lundan, 2008).

The research makes two unique contributions to innovation and institutional theories. First, this research contributes to the innovation literature in developing economies once, in the 21st century, the rise of knowledge and the global center for research and technology are shifting towards developing countries (Casanova and Miroux, 2019). Moreover, despite the popularity of institutional studies, there is a misunderstanding between these two key concepts in developing economies (Alam et al., 2019a; Sun et al., 2018), especially in Latin American countries, which innovation studies initiated later (Pérez et al., 2019; Viglioni et al., 2020). In the meantime, whereas some authors contributed exploring Asia (Andrés and Min, 2020; Sun et al., 2018), East Africa (Barasa et al., 2017), and other developing and transition economies (Alam et al., 2019b), we extend the research to Latin American countries.

Our research is designed based on novel and exclusive data from local Latin firms. Such analysis deserves special attention once we considered countries with particularly relevant R&D expenditure (see UNESCO, 2021) and considerable innovation effort (Fleury et al., 2013; Crespi et al., 2014; Pérez et al., 2019). Consider the Latin America scenario is invaluable because institutions vary by region and country (Barasa et al., 2017; Meyer et al., 2009). Therefore, Latin American countries contribute by offering a potential research background, once Latin America was founded through a rough colonization process from Spanish and Portuguese empires, implying an institutionally complex environment (North, 1990).

Second, following past literature (e.g., Alam et al., 2019a; 2019b; Hillier et al., 2011; Sasidharan et al., 2015), our research adopts the GMM estimator using the instrumental variable (IV) to address the endogeneity issues. Looking forward to increasing robustness, we contribute to developing three institutional sub-area components extracted from Kaufmann et al. (2011). This new approach allows to address multicollinearity, and, at the very least, contributes to offering frictionless and robust indicators to evaluate institutions at the country- and firm-level in further research. Ultimately, we strongly suggest that findings yield promising implications

for policymakers to continue developing and advancing institutions to sufficiently achieve long-term R&D performance.

The remainder of the paper is organized as follows. Section two describes the extant theoretical framework and the hypotheses. The third section outlines the methods. Section four estimates the model. Section five describes the results and robustness checks. Finally, the last section discusses the results with policy and managerial implications and the conclusions.

2. Theoretical framework and hypotheses

2.1. Country institutional environment and firm R&D investments

As a social phenomenon, institutions play a crucial role in legitimizing the firm's activities (DiMaggio and Powell, 1983; Scott, 1995), a subject that pulled together to economic activities (North, 1990; 1991; Williamson, 2000). Drawing on a broad construed, institutions are fundamental for the firms and country's economic growth (Acemoglu and Robinson, 2008; Svensson, 2005). Taking this into consideration, the countries' institutional environments are complex and can be unfolded in two major significant dimensions – formal and informal institutions (Fleury et al., 2013).

These two dimensions are underpinned by three "pillars" – regulatory, normative, and cognitive (Peng et al., 2009). The formal institutions, as North's (1990) drawn "the rules of the game". These rules, by their very nature embrace laws, regulations and rules as the regulatory/coercive pillar (DiMaggio and Powell, 1983; North, 1990; Scott, 1995). On the other hand, the informal institutions include the normative pillar, commonly accepted as informal societal and cultural prescriptions, such as the values, beliefs, and actions; whereas the cognitive one denotes the shared social knowledge and conceptions of reality in a particular society (Cuervo-Cazurra et al., 2019a; Scott, 1995). Remarkably, institutions acts as an essential role in supporting the proper functioning of society and control the behavior of individuals and firms (Cuervo-Cazurra et al., 2019a).

Recognizing this, institutions breathe across the world. Thereby, institutions reveal many unique features, especially in developing economies that generally do not exist or frequently happen in more advanced countries (Rottig, 2016). Considering these specific characteristics, Cuervo-Cazurra et al. (2019a) highlight that institutional quality facilitates market transactions, representing the interests of most individuals and establishing norms to achieve their objectives. Specifically, Mahmood and Rufin (2005) developed a broad model

based on institutional quality to understand how quality affects the firm innovation, the flow of resources, and the knowledge spillover from innovation. For instance, the country's institutional quality is connected to the development of institutions that support innovation in its market (Wu et al., 2015), which includes R&D (Alam et al., 2019b). By contrast, low-quality institutions imply a less business-friendly environment, inadequate provision of public goods and services, lack of R&D support to leverage private activities (Bianchini et al., 2019), and high transaction costs (Williamson, 2000).

Another essential classification relies on its strength. Institutional strength refers to the level of control over individuals and companies (Cuervo-Cazurra et al., 2019a). For example, strong institutions reduce uncertainty, creating structures favorable to the execution of established contracts, thereby reducing transaction costs (Fleury et al., 2013). In this vein, institutions ensure the returns from an uncertain investment by managing their risk (Edquist and Johnson, 1997). On the other hand, weak institutions fail to ensure an effective market (Meyer et al., 2009). For these and other reasons, stronger institutional settings likely help to foster R&D investments and improve knowledge in a country (Alam et al., 2019a). More specifically, a rare classification relies on institutional voids, where countries have institutions or not (Cuervo-Cazurra et al., 2019a). In this perspective, firms will face more uncertainty in the presence of voids or underdevelopment of certain institutions (Rottig, 2016). Nonetheless, countries rarely lack institutions – i.e. institutional voids (Cuervo-Cazurra et al., 2019b).

Assuming that R&D intensive countries show well-functioning institutions (Peng et al., 2008; Wu et al., 2016), we argue that R&D investments in developing economies are surrounded by the shadows of an under-developed and risky institutional environment. Applying this line of thinking to economic institutions (North, 1990; 1991) and considering the fact that Latin American countries are investing in R&D activities, we contend that their institutional conditions may impact this important knowledge activity. Holding these suppositions, we explain that the six governance institutional influences, such as – voices and accountability, government effectiveness, rule of law, control of corruption, political stability, and regulatory quality – act as moderators encouraging or even discouraging the R&D investment and the firm performance, depending on the institutional development of each country.

2.2. Hypotheses development

2.2.1. R&D investments and voice and accountability

Voice and accountability reflect the democracy of a country (Wu et al., 2016) and captures the perceptions of the extent to which the citizens are able to participate in selecting of their government, as well as freedom of expression, freedom of association, and free media (Kaufmann et al., 2011). For instance, North (2000, p. 51) claim that "democratic government gives a greater and greater percentage of the populace access to the political decision-making process, eliminates the capricious capacity of a ruler to confiscate wealth, and develops third-party enforcement of contracts with an independent judiciary, the result is indeed a move toward greater political efficiency." Therefore, one function of a well-established democratic system is to protect property, facilitate human development and encourage innovation investments (Wu et al., 2016).

However, developing economies suffer from at least one or several transparencies, lack of democracy, and freedom rights issues. In extreme situations, one paragon case emerges from the Bolivarian Republic of Venezuela. The situation is much more than a complex case because it is a paradox, where a Dictator governs the so-called democratic' State. Meanwhile, in 2020 Chile approved a historical plebiscite to start a new constitution – that might result in a more socially democratic place. Such a situation is relevant for firms and well documented by Acemoglu et al. (2019) because democratization through constraining kleptocratic dictators increases GDP in the long run. For this and other reasons, in a democratic country with high GDP, firms access more R&D activities (Alam et al., 2019a).

Consistent with this reasoning, more democratic institutions help to control the use of power by the government, ensuring that government policies, including innovation, are well aligned with the private investments – i.e. R&D (Wu et al., 2016). Moreover, better accountability helps the availability of external financing for R&D (Hillier et al., 2011). This suggests that high accountability ensures responsible decisions, actions, and commitment to accomplishing the R&D tasks (Alam et al., 2020). Therefore, it is likely that countries with a stable democratic system, where people can share their opinions and ideas may invest more in R&D activities. Considering these arguments, we propose the following hypothesis:

Hypothesis 1. Countries with high voice and accountability positively affect the relationship between R&D investments and the firm's R&D performance.

2.2.2. R&D investments and government effectiveness

In recent years, competition from domestic and foreign firms has substantially increased due to globalization and the liberalization of internal markets (Cuervo-Cazurra et al., 2019b). For instance, Singh and Gaur (2013) argued that in 1991, India faced a severe fiscal crisis that prompted it to undertake significant economic reforms, such as deregulations and privatizations to attract foreign players. The authors explain that, domestic firms were forced to invest in R&D to remain competitive. In line with this argument, Sun et al. (2018) documented that local government deregulation in the Chinese pharmaceutical sector positively impacted the R&D intensity. Such a process is important to facilitate market transactions and limit the role of the government in the economy (Cuervo-Cazurra et al., 2019b).

Moreover, effective governments can provide high-quality civil services, such as education, knowledge diffusion and human development (Wu et al., 2016). Taken together, governments collaborate on R&D programs fostering innovation networks (Mahmood and Rufin, 2005). From the strategic perspective of R&D, governments can "helps the firm secure unique technological resources and outputs of publicly-funded R&D and increases the variety and quality of R&D inputs and thus enhances the effect of R&D intensity" (Yi et al., 2017, p. 3). This is well documented by Bianchini et al. (2019), analyzing several European economies. The authors found that efficient government institutions are a key factor in R&D subsidies. Conversely, poor government effectiveness may dent the impact of policies to promote firm innovations and R&D investments (Alam et al., 2019a; Singh and Gaur, 2013). Considering these arguments, we propose the following hypothesis:

Hypothesis 2. Countries with high government effectiveness positively affect the relationship between R&D investments and the firm's R&D performance.

2.2.3. R&D investments and rule of law

Another challenge posed to firms' R&D investments is related to the rule of law. In the words of Kaufmann et al. (2011, p. 223), the rule of law captures the "perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence". Thus, in countries where the rule of laws is well-defined and transparent, it may encourage investment, entrepreneurship, and innovative activities (Wang et al., 2015). Examples of practices that involve a well-established rule of law can be explained in different ways.

First, country's that protect the shareholder's rights, offering legal protection leads to more incentives to undertake R&D expenditures (Iturriaga and López-Millán, 2017; Pindado et al., 2015). For instance, Seitz and Watzinger (2017) discovered for 23 OECD countries that firms invest more in R&D in economies with better contract enforcement. Recent evidence suggested that strong economic and legal institutions encourage firms to raise funds from capital markets rather than relying solely on banks (Alam et al., 2019b). This is because one of the capabilities for a company to invest in R&D relies on the availability of financial funds (Un and Montoro-Sánchez, 2011). In this vein, Alam et al. (2020) noted that R&D investments generate higher profits in countries where investor protection is stronger. Conversely, in the presence of poor-quality institutions, contract enforcement will be difficult (Sun et al., 2018). In sum, a reliable legal institution is crucial to boost firm investments, for example, because it leads to higher credit availability (La Porta et al., 2008).

Second, legal institutions also influence the availability and cost of innovation inputs and the protection of innovation outputs, reflected, for example, by the intellectual property rights (IPRs) (North, 1990). The IPR mechanisms are powerful instruments that reduce the probability of imitation and enable firms to collect the rewards generated from innovation investments (Wang et al., 2015; Wu et al., 2016). For instance, Bianchini et al. (2019) revealed that property rights protection is positively associated with firm innovation performance. Conversely, Pérez et al. (2018) concluded that firms could reduce their investments in R&D when the IPRs environment is underdeveloped. Without such protection, firms are discouraged to invest in R&D, once their innovation outputs can be easily imitated and quickly diffused (Sun et al., 2018). Overall, firms operating in an economy with weak legislative institutions, such as IPRs, will encounter high transaction costs and uncertainty, limiting their R&D investments (Pérez et al., 2018). Considering these arguments, we propose the following hypothesis:

Hypothesis 3. Countries with strong rule of law positively affect the relationship between R&D investments and the firm's R&D performance.

2.2.4. R&D investments and control of corruption

In developing countries, it is not rare that firms bribe government officials to grant licenses, permits, or preferential treatments (Andrés and Min, 2020; Cuervo-Cazurra, 2008; Paunov, 2016). In particular, corruption activities reflect the country's legal, economic,

cultural, and political institutions (Svensson, 2005). Researchers documented that a corrupted environment reduces the magnitude of the possibility for firms to invest in R&D and, subsequently, the returns to R&D investments (Alam et al., 2019a) lowering the innovation outputs (Svensson, 2005) in favor of the high transaction costs (Williamson, 2000).

For example, in East Africa, Barasa et al. (2017) demonstrated that innovators are often subjected to extortion from government officials requiring licenses and permits, reducing the firm's potential R&D investments to develop new innovative products. In such environments, the firm's R&D investments become to make it more uncertain and less profitable (Alam et al., 2019a). This is because several developing countries still suffer from a lack of control of corruption (Alam et al., 2020). In particular, some studies in Latin America showed that corruption is a barrier to innovating for small-medium enterprises (SMEs), lowering different types of innovation investments or R&D (Paunov, 2016). Considering these arguments, we propose the following hypothesis:

Hypothesis 4. Countries with high level of control of corruption positively affect the relationship between R&D investments and the firm's R&D performance.

2.2.5. R&D investments and political stability and absence of violence/terrorism

At this phase of the rules of the game, the stability of a political system can affect the environment in which firms operate (Tan and Chintakananda, 2016). In a stable political environment, innovators are encouraged to take new initiatives (Wu et al., 2016), whereas, for R&D investments, it is not different (Alam et al., 2019a). Conversely, in the presence of instability, frictions are likely to arise to financing R&D activities (Sasidharan et al., 2015). Therefore, when firms operate in unstable political contexts, their investments might be negatively affected.

As an example, the Brazilian' political uncertainty caused an economic freefall in 2016 since the end of dictatorship in 1985 because the Brazilian Congress voted in favor of sending the Senate the impeachment charges against the ex-president Dilma Rousseff (The Economist, 2016). To make the political stability worse, the FDI inflows from the largest advanced, transition and developing economies felled around 42 percent in 2020 in virtue of the COVID-19 pandemic, resulting in lower a value since the 2009 global financial crisis (UNCTAD, 2021). Therefore, seems likely that if the country is experiencing a political *cul-de-sac*, managing

rough external friction and invest in riskier and expensive activities, such as R&D and other knowledge activities will be challenging.

Specifically, when the firm operates in an unstable political environment, its local currency is deteriorated, making it hard to finance R&D activities (Alam et al., 2020). This is a typical institutional setting in developing economies that discourages and constrains R&D and other knowledge investments (Barasa et al., 2017). Therefore, such instability becomes even more relevant in the context of R&D activities due to the uncertain returns and sunk costs (Bianchini et al., 2019; Sun et al., 2018). By contrast, Tan and Chintakananda (2016) noted for 40 countries that low political stability directly increases firm performance, once excessive certainty may reduce the opportunity for development. Finally, in an extreme case, Uddin et al. (2021) documented that terrorism has higher negative implications for innovation in developing than developed economies due to the strong institutional settings provide by the latter. Considering these arguments, we propose the following hypothesis:

Hypothesis 5. Countries with high political stability positively affect the relationship between R&D investments and the firm's R&D performance.

2.2.6. R&D investments and regulatory quality

Government regulations are a key component of developing economies' environment (Yi et al., 2017). The regulatory quality "capturing perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development" (Kaufmann et al., 2009, p. 223). For this and other reasons, extant literature showed that good regulatory quality increases investment opportunities (i.e. R&D) because it helps firms with market entry and to keeps up-to-date with developments (Alam et al., 2019a, 2019b). Furthermore, the level of regulatory effectiveness can also influence the "rules of the game", providing effective transactions between firms and other actors or stakeholders (Tan and Chintakananda, 2016), which facilitates R&D investments.

In this regard, Andrés and Min (2020) identified that higher regulatory quality facilitates innovation for Chinese firms. Moreover, Tan and Chintakananda (2016) found that regulatory effectiveness directly enhances firm performance due to the enforcement and transparency, which facilitates a firm's transactions and the recombination of resources. Finally, Li and Ferreira (2011) indicated that small firms in Europe are more vulnerable to finance their

activities when regulatory institutions are less effective. Therefore, and considering these arguments, we propose the following hypothesis:

Hypothesis 6. Countries with strong regulatory quality positively affect the relationship between R&D investments and the firm's R&D performance.

3. Methods

3.1. Data description

We test and evaluate each hypothesis considering unique dataset from multiple Trade and Stock Markets exchanges from Brazil, Chile, Mexico, and Peru. Considering this data is invaluable once R&D studies in Latin America are still under-researched. Moreover, our study analyzes a large number of Latin firms, different from past research that considered a very low number of firms from this region (see Alam et al., 2019a; Alam et al., 2020). We collected all financial information (firm consolidated annual report) from B3 (*Brasil, Bolsa e Balcão*), formerly the "The Brazilian Stock Exchange", *La Comisión para el Mercado Financiero* – CMF from Chile, *Bolsa Mexicana de Valores*, S.A.B. de C.V., or BMV Group from Mexico, and *Bolsa de Valores de Lima* – BVL (Peru Stock Exchange). Specifically, the Consolidated Financial Statement and Balance Sheet offer the advantage to eliminate any structural investments. Thereby, the possibility of duplicity in R&D investment through affiliated firms is ruled out (Iturriaga and López-Millán, 2017, p. 148). Other information that was not provided by Financial Statements was further collected on each firm webpage.

Table 1. Frequency and number of firms and R&D descriptive statistics

Country	No. of local firms	% of firms	Panel distribution		R&D Performance		R&D intensity	
			Freq.	%	Mean	Median	Mean	Median
Brazil	127	45.81	261	94.91	3.492	3.450	11.716	11.558
Chile	63	23.00	5	1.82	3.982	3.964	12.144	12.246
Mexico	38	13.88	4	1.45	3.654	3.622	12.324	12.851
Peru	47	17.31	5	1.80	4.108	4.078	11.632	11.268
Total	275	100	275	100	3.734	3.684	11.884	11.846

Note: Values presented in R&D performance and R&D expenditure columns are based on estimates from the dependent variable and the main independent variable, respectively.

To create our sample, we considered all financial data for firms belonging to the manufacturing sector. To avoid generalizations, we restricted the analysis only to local Latin firms (public & private) because foreign firms have different R&D spectrums and less severe

reporting requirements in the host country (Sasidharan et al., 2015). In addition, we limited the financial data only for countries with at least 30 firm-year observations by country (Hillier et al., 2011; Pindado et al., 2015) to avoid any biased analysis due to the low number of listed firms in small Latin economies. For this reason, it was not possible to collect data for other Latin American countries. Table 1 shows the frequency of firms and R&D descriptive statistics.

The collected data followed the International Financial Reporting Standards – IFRS. This is important because the financial report requirements from each country, private and public listed firms are constantly pressured by their institutional investors to promote R&D and other knowledge activities that generate value-added (Iturriaga and López-Millán, 2017). Moreover, it is worth mentioning that, albeit firms follow the IFRS, firms have the option to financially inform their balance and assets in the current national currency. Thereby, values accounted in BRL, Mexican and Chilean Pesos, and Peruvian Nuevo Soles were standardized to million U.S. dollars. After dropping observations with missing data, the sample follows an unbalanced panel distribution, which mitigates the survivorship bias problem and allows to control the individual heterogeneity (Hillier et al., 2011; Pindado et al., 2015). Our final sample consists of 275 firms and 1.883 observations during the time period 2012–2019.

3.2. Variables and measures

3.2.1. Dependent variable

The dependent variable is R&D performance, measured as the firm's R&D expenditures over total sales (Singh and Gaur, 2013; Un and Montoro-Sánchez, 2011). We adopted this proxy for R&D performance once the firm performance depends not only on the R&D investments but on firm sales, thereby one of the main reasons why firms invest in R&D activities.

3.2.2 Independent and moderating variables

The main independent variables is represented by $R\&D_{t-1}$ investment, measured by the natural log of total R&D expenditure of a firm *i* at time period *t*. We operationalize the lagged R&D investments based on the firm's stock of knowledge. Nonetheless, the financial reports do not offer such information. Alternatively, Kafouros (2008, p. 101) suggests the Frascati Manual guideline, offering three main components to operationalize the firm's R&D investments: Capital, Labor, and other current expenditures. The firm capital includes (e.g.,

buildings, lands, terrains, vehicles, and machines). To measure the labor, we adopted a proxy for a firm total amount of wages and salaries (Tsai, 2005). For instance, Hall and Lerner (2010) state that more than 50 percent of spending on R&D is directed to innovators' salaries.

Moreover, the other firm current expenditures include (e.g., computers, software, equipment and other assets). We followed this approach once R&D is very different from other corporate investments, representing all direct and indirect costs related to the creation and development processes (Hillier et al., 2011). More specifically, we adopted the rate of obsolesce of the knowledge to estimate the stock of R&D (Griliches, 1979), as Equation (1) indicates:

$$\mathrm{R_{it}} = \mathrm{RD_{it}} + \sum_{1}^{k} (1-\delta)^{k}\, \mathrm{RD_{i(t-k)}} \tag{1}$$

Term *k* represents the lagged year, the R&D capital of a firm *i* at time *t* is represented by (R_{it}), which depends on past and current R&D expenditures (RD). The weighting factor δ is a suitably geometrically declining depreciation rate (Kafouros, 2008). The depreciation rate reflects the replacement of old knowledge by new knowledge or the reduction in the effective appropriation of knowledge (Tsai, 2005). In line with Kafouros (2008) and Tsai (2005), we considered 20 percent as the depreciation rate of R&D.

Regarding country-specific characteristics as moderating variables, we followed prior research adopting the dimensions of governance from the Worldwide Governance Indicators as the traditions and institutions by which authority in a country is exercised (e.g., Alam et al., 2019a; Alam et al., 2020; Kaufmann et al., 2011). These indicators are often used in studies that examine cross-country differences and institutional environments (Wu et al., 2016). Each of the six estimates ranges from – 2,5 (weak) to 2,5 (strong). These six influences are encompassed by the following three major areas (see Kaufmann et al., 2011, p. 223). The first area is composed of *the process by which governments are selected, monitored, and replaced*: (a) voice and accountability (VA) and (b) political stability and absence of violence/terrorism (PV). The second area consists of *the capacity of the government to effectively formulate and implement sound policies*: (c) rule of law (RL) and (d) government effectiveness (GE). The third area is represented by *the respect of citizens and the state for the institutions that govern economic and social interactions among them*: (e) regulatory quality (RQ) and (f) control on corruption (CC).

3.2.3. Control variables

We controlled for several firm characteristics that may influence the R&D performance. First, we controlled for a firm's sales growth, measured by the changes in sales over total sales (Alam et al., 2019b). Second, we included the firm leverage, operationalized as the total debt over total assets (Alam et al., 2020). We considered the firm leverage because long-term R&D investments depend on the current level of leverage, thereby influencing the firm involvement with innovation (Un and Montoro-Sánchez, 2011). Third, we controlled the firm age measured as the logarithmic transformation of the number of years since firm was founded (Yi et al., 2017; Wu et al., 2016). Firm age might influence the R&D performance, once young firms generally show highly innovative patterns (Crespi et al., 2014). Fourth, we accounted for the firm size, which is often regarded as a core significant to invest in innovation activities (Tsai, 2005). We measured the size as the natural logarithm of firm total assets (Alam et al., 2019a; Iturriaga and López-Millán, 2017).

We introduced a set of time-specific dummies to capture variations in business cycles and for possible effects of serial correlation. Finally, we controlled for the technology intensity dummy, 1 if the firm is from the high-technology sector; 0 otherwise. This variable reflects the technology intensity once the literature predicts that high-technology industries show higher R&D investments (Kafouros, 2008; Sasidharan et al., 2015). Table 2 presents the summary of variables and definitions.

Table 2. Summary of variables and definitions

Variables	Description
R&D performance	R&D expenditures over firm total sales
R&D	Natural log of the firm R&D investments
$R\&D_{i,t-1}$	Natural log of the lagged firm R&D investments
CC	Score ranges from –2.5 (weak) to 2.5 (strong) controls of corruption
GE	Score ranges from –2.5 (weak) to 2.5 (strong) governance effectiveness
VA	Score ranges from –2.5 (weak) to 2.5 (strong) voice and accountability
PV	Score ranges from –2.5 (weak) to 2.5 (strong) political stability
RQ	Score ranges from –2.5 (weak) to 2.5 (strong) regulatory quality
RL	Score ranges from –2.5 (weak) to 2.5 (strong) rule of law
Sales	Firm's sales annual growth
Leverage	Firm total debt over total assets
ln age	Natural logarithm of years since the firm's establishment
ln size	Natural logarithm of total firm assets
Time dummy	Time dummy from 2012 to 2019
Industry dummy	Firm takes value 1 if they are from high-tech sector; 0 otherwise

Notes: CC = Control of Corruption; GE = Government Effectiveness; VA = Voice and Accountability; PV = Political stability and absence of violence/terrorism; RQ = Regulatory Quality; RL = Rule of Law.

4. Estimating the model

Our basic empirical design is represented by Equation (2). The dependent variable, firm's performance, is indicated by *R&D performance*$_{i,t}$ with the respective lagged term *R&D performance*$_{i,t-1}$. The explanatory variable is indicated by the firm R&D intensity represented by $R\&D_{i,t}$ and the lagged term $R\&D_{i,t-1}$. The institutional variables correspond to voices of accountability (*VA*), government effectiveness (*GE*), rule of law (*RL*), political stability (*PL*) and control of corruption (*CC*), and regulatory quality (*RQ*). To verify the impact of the lagged $R\&D_{i,t-1}$ with each institutional factors, two-way interaction were added. The control variables are indicated by firm $Sales_{i,t}$, $Leverage_{i,t}$, $Age_{i,t}$, and firm $Size_{i,t}$. The term γ indicates dummy variables to control the time effect idiosyncrasies and η representing a dummy for industry-technology intensity, once R&D is strongly related to a firm's specific business activities (Hillier et al., 2011; Kafouros, 2008). Finally, the residual of the regression is represented by $u_{i,t}$.

$$
\begin{aligned}
R\&D\ performance_{i,t} = {} & \alpha + \beta_1 R\&D\ Performance_{i,t-1} + \beta_2 R\&D_{i,t} + \beta_3 R\&D_{i,t-1} \\
& + \beta_4\left(R\&D_{i,t-1} \times VA_{i,t}\right) + \beta_5\left(R\&D_{i,t-1} \times GE_{i,t}\right) + \beta_6\left(R\&D_{i,t-1} \times RL_{i,t}\right) \\
& + \beta_7\left(R\&D_{i,t-1} \times PV_{i,t}\right) + \beta_8\left(R\&D_{i,t-1} \times CC_{i,t}\right) + \beta_9\left(R\&D_{i,t-1} \times RQ_{i,t}\right) \\
& + \beta_{10}\left(Sales_{i,t}\right) + \beta_{11}\left(Leverage_{i,t}\right) + \beta_{12}\left(Age_{i,t}\right) + \beta_{13}\left(Size_{i,t}\right) + \gamma_t \\
& + \eta_i + u_{i,t}
\end{aligned}
\tag{2}
$$

As observed, there is a significant chance of endogeneity, once the explanatory variable may be determined by the independent variable and *vice versa*. For instance, interacting the lagged R&D with each institutional factor may restrict or encourage the firm's lagged R&D investments, since deciding the amount to invests in R&D is likely to be affected by previous year events (Un and Montoro-Sánchez, 2011). Therefore, our model is configured in a dynamic panel to further avoid endogeneity and high serial correlation that occur in the static models (Wooldridge, 2002).

Table 3 presents the descriptive statistics and correlations. The correlations above 0.70 and 0.80 confirm the possibility of high multicollinearity between the institutional variables. However, someone may be concerned about the high level of correlation. To avoid possible misinterpretations, we provided robustness checks (detailed in section 5.2) to rule out any

doubts about multicollinearity. Briefly anticipating the robustness analysis, our analysis is not greatly affected by multicollinearity.

Alam et al. (2019a) discussed the several drawbacks of estimating the dynamic panel with the OLS. For instance, the OLS never consistently estimates the coefficient of lagged endogenous variables unless there is no heterogeneity (Wooldridge, 2002). Alternatively, GMM estimators (Arellano and Bond, 1991) have stronger assumptions that can make it more robust than fixed effect estimators, specifically when it becomes to the strict exogeneity of the regressors. For instance, GMM estimator is designed for models with a short time horizon (Blundell and Bond 1998; Roodman 2009a). In other words, it is largely recommended when the panel data have many individuals ($t \leq n$) but few observations. At the same time, GMM addresses the heteroscedasticity and autocorrelation issues that may arise due to the unobserved country heterogeneity (Arellano and Bond, 1991).

Consistently, we checked if panels contain a unit root to avoid spurious regression. There are numerous unit root tests, such as Levin-Lin-Chu, Harris–Tzavalis, Breitung, Im–Pesaran–Shin, to check if variables follow a stationary or non-stationary process. We applied the Fisher-type (Choi, 2001) based on Phillips–Perron tests once it offers robust results with serial correlation and heteroskedasticity matrix. Therefore, it is necessary to check the unit root hypothesis because they can evaluate the nature of the non-stationarity that the data exhibit (Phillips and Perron, 1988).

Table 3. Pairwise correlations between variables

Variables	Mean	S.D.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) R&D performance	3.734	1.087	1.000											
(2) R&D	11.884	2.010	0.260***	1.000										
(3) CC	–0.033	0.744	0.103***	0.060***	1.000									
(4) GE	0.141	0.545	0.123***	0.095***	0.918***	1.000								
(5) VA	0.474	0.346	0.069***	0.033	0.942***	0.791***	1.000							
(6) PV	–0.222	0.396	0.091***	0.049**	0.887***	0.745***	0.928***	1.000						
(7) RQ	0.394	0.604	0.184***	0.083***	0.847***	0.928***	0.681***	0.693***	1.000					
(8) RL	0.046	0.673	0.081***	0.060***	0.982***	0.908***	0.959***	0.893***	0.794***	1.000				
(9) Sales	–0.521	21.377	–0.126***	0.007	0.011	0.009	0.013	0.000†	–0.001	0.016	1.000			
(10) Leverage	0.614	0.515	0.085***	–0.112***	–0.120***	–0.181***	–0.041	–0.078***	–0.254***	–0.087***	–0.024	1.000		
(11) ln age	3.975	0.654	–0.018	–0.048**	0.092***	0.078***	0.103***	0.090***	0.076***	0.097***	–0.006	0.035	1.000	
(12) ln size	13.256	1.925	–0.028	0.909***	0.020	0.036	0.017	0.022	–0.002	0.031	0.012	–0.131***	–0.105***	1.000

Notes: Level of significance: * < 0.10, ** < 0.05, *** < 0.01. † = 3E–04.

Table 4 summarizes four statistics' values (P, Z, L*, and Pm) that must be in conformance with each other. When the tests are all significant, we can reject the null hypothesis (h0: All panels contain unit-roots). Thereby, the test suggests that R&D performance, R&D, CC, Sales, Leverage, Age, and Size, strongly rejected the null hypothesis. On the other hand, GE, VA, PV, RQ, and RL follow a stationary process. Although the inverse normal Z statistic offers the best trade-off between size and power (Choi, 2001) and the L∗ test typically agrees with the Z test, we included PV in the group of the stationary variables to avoid concerns about the null hypothesis. Finally, in line with Alam et al. (2019a), system GMM is preferable over difference GMM.

Table 4. Fisher-type test based on Phillips–Perron panel unit root

Variables	Inverse chi-squared [P]	Inverse normal [Z]	Inverse logit t [L*]	Modified inv. chi-squared [Pm]
R&D Performance	1426.517***	–8.301***	–15.252***	26.428***
R&D	1382.941***	–4.436***	–12.560***	25.114***
CC	916.958***	–11.766***	–11.435***	11.064***
GE	430.399	1.133	1.381	–3.606
VA	230.590	10.884	10.017	–9.630
PV	538.945	–3.860***	–3.617***	–0.333
RQ	407.280	6.237	7.059	–4.303
RL	258.700	7.677	6.825	–8.783
Sales	2046.200***	–20.425***	–30.569***	45.254***
Leverage	3646.216***	–26.100***	–53.155***	93.354***
ln age	1.950***	–133.184***	–325.966***	572.469***
ln size	1036.516***	–1.874**	–6.532***	14.669***

Notes: All panel unit root tests were performed including the constant and one lag level for all variables. Level of significance: * < 0.10, ** < 0.05, *** < 0.01.

We considered the xtabond2 Stata module for two-step system GMM because it makes it more robust than one-step (Roodman, 2009b). Besides difference GMM corrects the endogeneity, system GMM adds extra moments conditions with more instruments (Wooldridge, 2002). This increases efficiency transforming the instruments to make them uncorrelated with fixed effects (Arellano and Bover, 1995; Blundell and Bond, 1998). Although this results in more efficiency, add many instruments may implicate over-identification with large p-values for the Hansen J-test that tend to become inflated with an increase of instruments.

Considering an alternative solution, we used the xtabond2 collapse sub-option to limit the number of instruments and prevent an over-fitted model (Roodman, 2009a). In addition, we managed the lagged values (t–1), (t–2), (t–3), and (t–4) for the difference equation and (t–1), (t–2), and (t–3) lagged values for the level equation instruments. We believe this is an optimal lag value because using deeper lags may cause a trade-off between the instruments' validity

and their strength. Ultimately, we adopted two-step system GMM with robust standard errors once it offers a proper specification related to heteroscedasticity and autocorrelation (Roodman 2009a, 2009b).

5. Results and robustness analysis

5.1. Main results

Table 5 presents the empirical results for Models 1–13. As a routine, all models indicate that the AR(2) test does not reject the null hypothesis of no second-order serial correlation. In addition, the Hansen J-test for correlation between the instruments and the error term are non-statistically significant ($p < 0.10$), suggesting that the use of instruments is valid in all model specifications. Specifically, the Hansen test for the transformed equation based on lagged levels of R&D performance are all validated.

Model 1 shows the regression results only with control variables. Considering the firm performance, it is possible to observe that the current firm's R&D intensity positively impacts the firm's R&D expenditure across all models. Nonetheless, our obtained results are the inverse of the observed by Alam et al. (2020). Different from the author, we infer that firms create benefits in the same year, albeit it depends on the nature of R&D investments. This is observed when the lagged R&D term shows negative statistical significance across all models. Our results also diverge from Alam et al. (2019a), which documented that lagged R&D reveals a long-term orientation.

Controversially to our findings, R&D investments truly demand a longer time horizon (Singh and Gaur, 2013). In a thoughtful disagreement, we clarify this finding suggesting firms that invest in R&D have specific characteristics and strategies designed for short-term periods due to the nature of their projects. For example, Brazilian companies do not show an expected strength in R&D (Fleury et al., 2013). Interestingly, this is also a typical issue concerning Latin America, once firms hardly invest in disembodied technology, which reflects incremental and adaptive innovation (Crespi et al., 2014). However, such condition is not the worst because investments in non-technological innovations are also relevant for developing economies (Pérez et al., 2019).

Table 5. Two-step System GMM estimator

R&D Performance	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13
$R\&D_{t-1}$ Performance	0.286**	0.352***	0.259*	0.356***	0.382***	0.302**	0.283**	0.382***	0.339**	0.331***	0.281***	0.351***	0.284**
	(0.143)	(0.092)	(0.147)	(0.093)	(0.117)	(0.129)	(0.125)	(0.101)	(0.133)	(0.111)	(0.090)	(0.094)	(0.127)
R&D	1.346***	1.487***	1.360***	1.447***	1.578***	1.416***	1.396***	1.610***	1.503***	1.404***	1.307***	1.461***	1.410***
	(0.232)	(0.253)	(0.296)	(0.241)	(0.274)	(0.275)	(0.300)	(0.320)	(0.220)	(0.236)	(0.177)	(0.248)	(0.261)
$R\&D_{t-1}$	–0.658***	–0.764***	–0.505*	–0.742***	–0.808***	–0.694***	–0.791***	–0.770***	–0.676***	–0.693***	–0.634***	–0.748***	–0.661***
	(0.251)	(0.227)	(0.291)	(0.216)	(0.250)	(0.258)	(0.275)	(0.287)	(0.227)	(0.213)	(0.153)	(0.222)	(0.253)
CC		0.072*	–2.640										
		(0.040)	(2.506)										
GE				0.107*	2.710**								
				(0.061)	(1.285)								
VA						0.161**	–6.762**						
						(0.080)	(3.211)						
PV								0.271**	–1.431**				
								(0.125)	(0.710)				
RQ										0.131*	–1.862***		
										(0.076)	(0.582)		
RL												0.077	–0.649*
												(0.050)	(0.368)
$R\&D_{t-1} \times CC$			0.221										
			(0.203)										
$R\&D_{t-1} \times GE$					–0.211**								
					(0.104)								
$R\&D_{t-1} \times VA$							0.552**						
							(0.257)						
$R\&D_{t-1} \times PV$									0.130**				
									(0.059)				
$R\&D_{t-1} \times RQ$											0.161***		
											(0.048)		
$R\&D_{t-1} \times RL$													0.060**
													(0.031)
Sales	–0.009***	–0.011***	–0.009***	–0.010***	–0.009***	–0.009***	–0.009***	–0.009***	–0.009***	–0.009***	–0.009***	–0.009***	–0.009***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Leverage	0.041	0.278	0.549*	0.307	0.595**	0.163	0.460*	0.545**	0.393*	0.421	0.028	0.242	0.178
	(0.110)	(0.227)	(0.326)	(0.235)	(0.257)	(0.254)	(0.242)	(0.242)	(0.235)	(0.264)	(0.106)	(0.232)	(0.244)
ln age	–0.180	–0.148***	–0.153	–0.150***	–0.061	–0.148**	–0.136*	–0.909***	–0.109**	–0.150***	–0.324	–0.152***	–0.158***
	(0.358)	(0.054)	(0.098)	(0.053)	(0.059)	(0.058)	(0.070)	(0.307)	(0.051)	(0.054)	(0.311)	(0.058)	(0.057)
ln size	–0.812***	–0.825***	–0.795***	–0.823***	–0.707***	–0.851***	–0.823***	–0.826***	–0.748***	–0.813***	–0.838***	–0.826***	–0.864***
	(0.148)	(0.137)	(0.210)	(0.131)	(0.169)	(0.163)	(0.161)	(0.121)	(0.178)	(0.135)	(0.127)	(0.140)	(0.157)
Constant	5.886***	5.131***	3.349***	5.268***	2.345***	5.667***	6.652***	6.756***	2.841***	5.050***	6.975***	5.286***	5.837***
	(1.787)	(1.075)	(0.963)	(1.024)	(0.840)	(1.181)	(1.764)	(1.403)	(0.805)	(1.076)	(1.433)	(1.110)	(1.111)
Industry-time dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	1883	1883	1883	1883	1883	1883	1883	1883	1883	1883	1883	1883	1883
Groups/instruments	275/37	275/36	275/34	275/36	275/36	275/37	275/33	275/34	275/37	275/36	275/38	275/35	275/38
Prob > F	21.69***	46.62***	26.27***	50.07***	25.58***	22.24***	58.86***	82.92***	25.47***	53.96***	33.53***	48.04***	22.60***
AR(1) p-value	0.017	0.003	0.014	0.003	0.002	0.009	0.009	0.005	0.004	0.004	0.005	0.003	0.009
AR(2) p-value	0.929	0.958	0.815	0.971	0.988	0.987	0.961	0.947	0.957	0.856	0.972	0.991	0.976
Hansen J-test	0.236(23)	0.412(21)	0.414(18)	0.341(21)	0.362(20)	0.343(22)	0.545(17)	0.572(19)	0.306(21)	0.316(21)	0.249(22)	0.308(20)	0.289(22)
Hansen for levels	0.471(15)	0.756(13)	0.803(10)	0.555(13)	0.499(12)	0.652(14)	0.869(9)	0.878(11)	0.531(13)	0.581(13)	0.467(14)	0.636(12)	0.492(14)

Notes: Dependent variable = R&D performance. Level of significance: * < 0.10, ** < 0.05, *** < 0.01. Standard errors in parenthesis and bellow each coefficient. The degree of freedom for Hansen J-test of overidentifying restrictions and for the equation level for R&D performance are between parenthesis. The 2017-time dummy was excluded due to a "glitch" of the Roodman xtabond2, which may engender an incorrect degree of freedoms and incorrect p-values for the Hansen test.

In the case of controls of corruption, Model 2 indicated a positive and statistical significance ($\beta = 0.072$, $p \leq 0.10$). This is consistent with Barasa et al. (2017) and Alam et al. (2020), explaining that high corruption negatively affects the firm internal R&D activities. Thereby, if corruption is rife, firms face more significant barriers to becoming innovative (Andrés and Min, 2020). However, in Model 3, the interaction between the lagged R&D and control of corruption does not show statistical significance. Therefore, we cannot infer about Hypothesis 4.

Model 4 lists the results for government effectiveness. Our findings are in line with Mahmood and Rufin (2005), Sun et al. (2018) and Alam et al. (2020). We identified that government effectiveness results in performance gains ($\beta = 0.107$, $p \leq 0.10$). However, in Model 5, the interaction between the lagged R&D and government effectiveness resulted in a negative effect ($\beta = -0.211$, $p \leq 0.05$). Thus, the results do not support Hypothesis 2. We explain that, although Latin American governments have improved their effectiveness, such as their openness to the foreign market, several countries (e.g., Brazil) have the status of protectionist by their global partners. Latin American countries may be facing a trade-off between developing local and nascent industries instead of opening their markets to stimulate competition and investments in R&D (e.g., Singh and Gaur, 2013). A tentative explanation, government effectiveness in Latin America is still a significant challenge to promote R&D in local industries, primarily due to the high bureaucratic level (North, 1990; Pérez et al., 2019; Viglioni et al., 2020).

Regarding voice and accountability, Model 6 showed a positive and statistical significance ($\beta = 0.161$, $p \leq 0.05$). At the same time, Model 7 showed a positive statistical significance when the lagged R&D interacts with voice and accountability ($\beta = 0.552$, $p \leq 0.05$), supporting Hypotheses 1. This holds the idea that more democratic and transparent countries, where people can share their voices and ideas, will attract more innovative activities such as R&D investments. Our finding is consistent with the results of Alam et al. (2020), when voice and accountability, in general, influence firm investments, i.e. R&D investments. This valuable finding complements recent research. In this regard, better voices and accountability, and more democracy, are relevant for the country's growth (Acemoglu et al., 2019), thereby influencing the firm's decision to invest in R&D (Alam et al., 2019a).

When political stability is the rule of the game, we observed in Model 8 that the coefficient showed positive and statistical significance ($\beta = 0.271$, $p \leq 0.05$). Moreover, in Model 9, the interaction between the lagged R&D and political stability resulted in positive R&D performance ($\beta = 0.130$, $p \leq 0.05$), supporting Hypothesis 5. However, our result differs

from Tan and Chintakananda (2016). For the regulatory quality, Model 10 suggests a positive coefficient ($\beta = 0.131$, $p \leq 0.10$). This finding enhances the idea that regulatory quality plays a significant determinant of R&D investment and directly enhances the firm's R&D performance due to enforcement and transparency while facilitating a firm's transactions and recombining resources. Model 11 showed a strong positive and significant coefficient between the interaction of the lagged R&D and regulatory quality ($\beta = 0.161$, $p \leq 0.01$). Thus, the results support Hypothesis 6. Moreover, this evidence complements Alam et al. (2020). Also, our finding is in line with Alam et al. (2019a) and Andrés and Min (2020), indicating that high quality of government regulations ensure a consistent R&D investment.

Model 12 showed that rule of law does not show significance ($\beta = 0.077$, $p > 0.10$). Nevertheless, in Model 13, the interaction between the lagged R&D and the rule of law indicated a positive significance ($\beta = 0.060$, $p \leq 0.05$), supporting Hypothesis 3. Accordingly, improvements in the rule of law in developing economies may positively alleviate market failures by providing a proper legal framework (Viglioni et al., 2020). Moreover, legal institutional factors, such as strong IPRs, influence the decision to innovate at the company level and invest in R&D activities (Crespi et al., 2014; Pérez et al., 2019).

Finally, considering the control variables, sales showed a negative coefficient across all models. This result was also observed by Sasidharan et al. (2015) but, at the same time diverge of Alam et al. (2020). Different from this author, we found positive leverage across few Models. In such cases, high leverage levels may limit the ability to invest in long-term R&D (Un and Montoro-Sánchez, 2011). Finally, firms R&D performance has a negative relationship between age and size. This is also consistent with Crespi et al. (2014), explaining that in Latin America, young firms are more dynamic and appear highly innovative, with significant R&D investments to introduce innovations at high rates.

5.2. Robustness tests

For the sake of robustness, in this subsection, we provide a series of additional checks to maintain the robustness of the main results provided by Table 5. In a first robustness test, we examine the elasticity of each institutional index. We showed how each institutional index plays an important role in explaining the firm's R&D investment. It is necessary to compare the strength of several institutional indexes that affects the relationship between a firm's R&D investments and R&D performance. In line with past researchers (e.g., Alam et al., 2020), we

adopted the elasticity index proposed by Hillier et al. (2011) to compare the explanatory power of each institutional variable. The elasticity is accounted by the following Formula.

$$E_i = \beta_i \frac{\bar{X}_i}{\beta^p \bar{X}}$$

According to Hillier et al. (2011), the elasticity is indicated by *E* and *i* is represented by each institutional variable. The parameter β_i denotes its coefficient. The term $\bar{X}_i$ represents the mean value, whereas the $\beta^p \bar{X}$ captures the predicted value of the dependent variable evaluated using the mean value of each regressor. Table 6 presents the explanatory power of each institutional factor concerning R&D performance. It is possible to observe that the highest explanatory power is noticed by voice and accountability (E_{VA} = 0.771). Second mostly influent variable is government effectiveness (E_{GE} = – 0.342), followed by regulatory quality (E_{RQ} = 0.224), political stability (E_{PV} = 0.195) and rule of law (E_{RL}= 0.083).

Table 6. Elasticity test

Variables	Elasticity
Control of corruption	0.296(0.254)
Government effectiveness	–0.342*(0.183)
Voice and accountability	0.771*(0.405)
Political stability	0.195**(0.079)
Regularity quality	0.224***(0.076)
Rule of law	0.083**(0.040)

Notes: Values presents parameter estimates from the two-step system generalized method of moments regressions based on each interaction model. Level of significance: * < 0.10, ** < 0.05, *** < 0.01. Standard errors are between parenthesis.

This result implies that the most important institutional drivers for a firm's R&D performance rely on better voice and accountability, government effectiveness, and regulatory quality. Finally, the earlier findings are quite robust. Therefore, the explanatory power from the elasticity test is in line with all interaction specifications from Table 5. In summary, the elasticity of each institutional variable is robust and equally related to their interaction effect, from the higher to the lower impact coefficient (E_{VA} = 0.771; Model 7) followed by (E_{GE} = – 0.342; Model 5), (E_{RQ} = 0.224; Model 11), (E_{PV} = 0.195; Model 9), and (E_{RL}= 0.083; Model 13).

In a second robustness test, we deal with multicollinearity. Previous studies have typically adopted the WGI indicators to assess firm performance (e.g., Alam et al., 2019a; 2019b, Alam et al., 2020). Nonetheless, most of the six institutional influences are a double-

edged sword once they are a very reliable source of information and, at the same time, show high collinearity due to the similarities in the construction of each indicator (see Kaufmann et al., 2011). Although past research adopted two-step system GMM with the Windmeijer (2005) correction and the use of instrumental variables (IV), we should be cautious because some misty degree of multicollinearity will persist. If multicollinearity persists, it may not bias the coefficients but could inflate the standard error, resulting in implausible p-values below a critical threshold.

To get over that, Wu et al. (2016, p. 6) proposed to submit the six WGI indicators to factor analysis to create a single index. Nonetheless, using a single estimate could cause a severe bias in our analysis. Alternatively, in an attempt to avoid doubts related to multicollinearity and construct a more fitted index to our research purpose, we propose to develop three indexes (according to Kaufmann's subcomponents described in Section 3.2.2). The first index represents the subcomponent from area 1 – composed of *the process by which governments are selected, monitored, and replaced* (voice and accountability + political stability and absence of violence/terrorism). The second for area 2, which consists of the capacity of *the government to effectively formulate and implement sound policies* (rule of law + government effectiveness). Finally, the third for area 3, which *the respect of citizens and the state for the institutions that govern economic and social interactions among them* (regulatory quality + control on corruption).

We submitted each area subcomponent to the Principal Component Analysis (PCA) to compose three indexes, called sub-area 1, 2 and 3. This procedure is much more reliable for such a situation, for example, because the Cronbach's alpha for each sub-areas is very high: sub-area 1 (Cronbach alpha > 0.9581), area 2 (Cronbach alpha > 0.9410) and area 3 (Cronbach alpha > 0.9063). After creating each sub-area component, it is worth considering the variance inflation factor (VIF) to avoid doubts over multicollinearity. The highest VIF value and the average estimated were 8.74 and 4.31, respectively. Effectively, all values are under the limit of 10 recommended by Hair et al. (2010). Table 7 provides insights from two-step system GMM considering each sub-area index.

Table 7. Robustness check for Two-step System GMM estimator with the sub-area index

R&D performance	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
$R\&D_{t-1}$ performance	0.374***	0.245*	0.354***	0.302**	0.294**	0.275**
	(0.104)	(0.138)	(0.095)	(0.118)	(0.125)	(0.122)
R&D	1.541***	1.294***	1.440***	1.345***	1.373***	1.293***
	(0.306)	(0.215)	(0.238)	(0.193)	(0.245)	(0.173)
$R\&D_{t-1}$	–0.758***	–0.535***	–0.736***	–0.630***	–0.650***	–0.554***
	(0.281)	(0.194)	(0.219)	(0.192)	(0.232)	(0.162)
Sub-area 1	0.091*	–0.580**				
	(0.053)	(0.248)				
$R\&D_{t-1}$ × Sub-area 1		0.052**				
		(0.020)				
Sub-area 2			0.056*	–0.378		
			(0.033)	(0.270)		
$R\&D_{t-1}$ × Sub-area 2				0.036*		
				(0.022)		
Sub-area 3					0.081*	–0.533*
					(0.048)	(0.291)
$R\&D_{t-1}$ × Sub-area 3						0.050**
						(0.023)
Sales	–0.009***	–0.009***	–0.010***	–0.009***	–0.009***	–0.009***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Leverage	0.391	0.112	0.301	0.316	0.429	0.389
	(0.278)	(0.279)	(0.240)	(0.265)	(0.282)	(0.333)
ln age	–0.842**	–0.141**	–0.149***	–0.164***	–0.140**	–0.339
	(0.364)	(0.058)	(0.054)	(0.056)	(0.054)	(0.331)
ln size	–0.880***	–0.912***	–0.830***	–0.862***	–0.821***	–0.874***
	(0.126)	(0.181)	(0.135)	(0.137)	(0.146)	(0.116)
Constant	7.787***	6.316***	5.394***	5.942***	5.166***	6.555***
	(1.966)	(1.170)	(1.007)	(1.057)	(1.225)	(1.324)
Industry-time dummy	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	1883	1883	1883	1883	1883	1883
Groups/instruments	275/33	275/38	275/36	275/39	275/37	275/38
Prob > F	623.05***	896.66***	1009.57**	908.66***	973.94	915.78***
AR(1) p-value	0.006	0.015	0.003	0.006	0.008	0.008
AR(2) p-value	0.986	0.921	0.972	0.942	0.865	0.892
Hansen J-test	0.579(18)	0.406(22)	0.346(21)	0.320(23)	0.380(22)	0.295(22)
Hansen for levels	0.903(10)	0.848(14)	0.628(13)	0.529(15)	0.583(14)	0.345(14)

Notes: Dependent variable = R&D performance; Sub-area 1 = (PCA between: VA + PV); Sub-area 2 = (PCA between: RL + GE); Sub-area 3 = (PCA between: RQ + CC). Level of significance: * < 0.10, ** < 0.05, *** < 0.01. Standard errors in parenthesis and bellow each coefficient. The degree of freedom for Hansen J-test of overidentifying restrictions and for the equation level for R&D performance are between parenthesis.

At first glance, the robustness checks are very satisfactory and indicate that the regression results from Table 5 are not greatly affected by multicollinearity. First, all second-order serial correlation tests and Hansen for overidentification of instruments are valid in all specifications. Second, the results from the three sub-area analyses show that all coefficients

and standard errors are almost near to the findings of Table 5. Third, all lagged values for R&D remain negative. Again, this strongly suggests that firms have difficulty sustaining long-term R&D investments. Fourth, the interaction effect between the lagged R&D and each sub-area remains positive. This indicates that institutions matter in support long-term R&D investments.

Nonetheless, we identified that the sub-area 2 index, which encompasses the government effectiveness, showed a positive signal when interacted with the lagged values for R&D. Perhaps because, in sub-area 2, the rule of law is present and strengthens the connection between government effectiveness. This result is valuable, once combining the rigor of law and practical effectiveness of government may improve the efficacy of R&D investments. Ultimately, the control variables showed in accordance with all estimations from Table 5, thereby validating our findings.

6. Discussion and conclusions

Adopting an institutional economic perspective (North, 1990; 1991), we proposed investigating how the firm's R&D performance is moderated by the relationship between R&D investments and the role of country institutions in Latin America. Our research implies important lessons to innovation and institutional literature in developing economies. While other research did this investigation (e.g., Alam et al., 2019a; 2019b; Barasa et al., 2017), our research specifically contributes to the small growing literature in Latin America and with a better understanding of R&D investments. Corroborating with past research (Acemoglu and Robinson, 2008; Acemoglu et al., 2019; Sun et al., 2018), we provided more evidence that "institutions matter" for a long-term R&D investment.

As a whole, institutions subtly breathe in Latin economies. Nonetheless, it is necessary to unmask reality. Our findings indicate a fundamental challenge in many developing economies related to the sufficiently low capacity to invest in R&D aiming the long run. For instance, economies from Latin America sharply depend on imports of technology aiming to solve their technological short-term activities (Viglioni et al., 2020). Generally, it appears firms rely on this "transitory" source of knowledge to increase revenues and financial growth before unlocking a true R&D investment.

The findings continue to provide several critical insights. First, we applied a robust estimator to investigate how the institutions impact the firm's R&D investments. The use of robust estimators is important, considering that our institutional variables implicate a high correlation. Second, the research contributed with three sub-area indexes to check a fair

common issue in past research, apparently unsolved. We checked any concerns in adopting the WGI indicators. Our analysis continues to support the use of such institutional indicators, resulting in more upsides than downsides. Therefore, we offered a new approach developing three sub-area components created from Kaufmann et al. (2011). This provides robustness about the use of WGI indicators and an excellent opportunity for future research to continue these sub-area indexes in a new research framework.

Moreover, our results also bear important policy and practical implications to foster R&D investments in Latin economies. In terms of policy implication, we critically highlight that "institutions matter". This result is self-suggestive per se. Line up the country's institutions with the firm's R&D investments is an invaluable implication for developing economies to attain a long-term R&D performance. Therefore, policymakers should wake up fast in their sense of commitment to improve institutions. Thereby, managers can safely double down the sheer amount of R&D aiming the long-term. For instance, when government effectiveness interacted with the lagged R&D investment, a negative effect on firm performance is observed. This may be related to the size of government in developing economies – if government enlarges, e.g., excess of bureaucracy and other market inefficiencies, the private sector tends to shrinks.

Paired with this, some firms that receive government subsidies must follow specific bills. For example, tax subsidies in developing economies, for government practical reasons, are mainly planned in line with their interest, which means firms that depend on such benefits may stifle their true innovative objectives. Moreover, leveraged firms might be loaded with costly loans and long-term debts, weakening innovative activities. Along the way, firms that receive subsidies could lower their innovative commitments, falling into lazy and passive activities due to the governmental safeguards in case of failure. Thereby, it is tremendously important that policymakers focus on government effectiveness development, or, at the very least, include in Latin economies' agenda the deregulation process to accelerate progress on R&D activities (Cuervo-Cazurra et al., 2019b; Singh and Gaur, 2013; Sun et al., 2018).

In terms of practical implications, our study highlights that is necessary to hard press the tough' policymakers and endorse efficient policies looking towards long-term R&D. While institutions are the "rules of the game", changing and affecting the firm's environment – the reciprocal idea that firms can change the institutions is also truly acceptable (Cuervo-Cazurra et al., 2019a). Far from isolated, this interchange between practitioners and policymakers is crucial to find ways to empower an innovative economy. We suggest that it is wiser to consider both sides and weigh and balance them. To be effective, if both parties are weighted peers, the

process to foster R&D is less risky and more advantageous. Thereby, instead of breaking interests into different parts, better yet is combines them to improve the long-term R&D activity in developing economies. Nonetheless, built these relationships won't happen overnight and are part of a rough process that only can be built under pressure. We urge future research to deep check this under-discussed relationship in the context of firms' R&D.

Finally, our research is not free of limitations. Although we focused only on four Latin American countries, the results cannot be generalized to other medium and small economies from the Latin region. While we have chosen the country governance indicators, it could be interesting to investigate other institutional traditions. In addition, future research should continue to explore other Latin economies to further understand the relationship between the institutional specificities and the R&D investments. Our policy implication is straightforward, such a light bulb on the opaque world of policymakers trying to develop a region surrounded by the shadows of underdeveloped institutions. Reiterating, we end this research with the following Thomas Alva Edison quote: "I didn't fail 1000 times. The light bulb was an invention with 1000 steps".

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APPENDIX

Appendix A – Summary of firms by firm name, ISIC rev. 4 and country (Continue)

N	Firm name	2-digit ISIC rev. 4	Country
01.	Battistella Administração e Participações S.A.	02	Brazil
02.	Minasmaquinas S.A.	29	Brazil
03.	WLM Participações e Comércio de Máq. e Veículos S.A.	29	Brazil
04.	Azevedo & Travassos S.A.	43	Brazil
05.	Eternit S.A.	23	Brazil
06.	Haga S.A. Industria e Comércio	25	Brazil
07.	Portobello – PBG S.A.	23	Brazil
08.	Taurus Armas S.A.	25	Brazil
09.	Stara S.A. Indústria de Implementos Agrícolas	20	Brazil
10.	Metisa – Metalúrgica Timboense S.A.	24	Brazil
11.	Bardella S.A. Indústrias Mecânicas	25	Brazil
12.	Electro Aço Altona S.A.	24	Brazil
13.	Indústrias Romi S.A.	25	Brazil
14.	Grupo Inepar S.A. Indústria e Construções	26	Brazil
15.	Kepler Weber S.A.	52	Brazil
16.	Metalfrio Solutions S.A.	27	Brazil
17.	Pratica Klimaquip Indústria e Comércio S.A.	28	Brazil
18.	Schulz S.A.	27	Brazil
19.	WEG S.A.	27	Brazil
20.	Embraer S.A.	30	Brazil
21.	Fras-le S.A.	29	Brazil
22.	Marcopolo S.A.	29	Brazil
23.	Metalúrgica Riosulense S.A.	24	Brazil
24.	Randon Companies S.A.	29	Brazil
25.	Recrusul S.A.	29	Brazil
26.	Tupy S.A.	24	Brazil
27.	Wetzel S.A.	27	Brazil
28.	Algar Telecom S.A.	61	Brazil
29.	Oi S.A.	61	Brazil
30.	Telefônica Brasil S.A.	61	Brazil
31.	Tim Participações S.A.	61	Brazil
32.	Iochpe Maxion S.A.	29	Brazil
33.	Mahle-Metal leve S.A.	29	Brazil
34.	Plascar Participações Industriais S.A.	29	Brazil
35.	Whirlpool S.A.	27	Brazil
36.	Arezzo Indústria e Comércio S.A.	15	Brazil
37.	Grazziotin S.A.	01	Brazil
38.	Guararapes Confecções S.A.	13	Brazil
39.	Lojas Renner S.A.	13	Brazil
40.	Marisa Lojas S.A.	13	Brazil
41.	Restoque Comércio e Confecções de Roupas S.A.	13	Brazil
42.	Mundial S.A.	13	Brazil
43.	Grupo Technos S.A.	26	Brazil

Appendix A – Summary of firms by firm name, ISIC rev. 4 and country (Continue)

N	Firm name	2-digit ISIC rev. 4	Country
44.	Alpargatas S.A.	14	Brazil
45.	Cambuci S.A.	14	Brazil
46.	Grendene S.A.	14	Brazil
47.	Vulcabrás-Azaleia S.A.	14	Brazil
48.	Cia Fiação Tecidos Cedro Cachoeira (Cedro S.A.)	13	Brazil
49.	Cia Industrial Cataguases	13	Brazil
50.	Cia Tecidos Norte de Minas – Coteminas	13	Brazil
51.	Cia Tecidos Santanense	13	Brazil
52.	Döhler S.A.	13	Brazil
53.	Empresa Nac. Com. Redito Participações (Encorpar S.A.)	13	Brazil
54.	Karsten S.A.	13	Brazil
55.	Pettenati S.A.	13	Brazil
56.	Springs Global Participações S.A.	13	Brazil
57.	Teka-tecelagem Kuehnrich S.A.	13	Brazil
58.	Textil Renauxview S.A.	13	Brazil
59.	C&A Modas S.A.	14	Brazil
60.	Cia Hering S.A.	14	Brazil
61.	Unicasa Indústria de Móveis S.A.	31	Brazil
62.	Bicicletas Monark S.A.	30	Brazil
63.	Manufatura de Brinquedos Estrela S.A.	32	Brazil
64.	Brasilagro – Cia Brasileira de Propriedades Agrícolas	01	Brazil
65.	Pomi Frutas S.A.	01	Brazil
66.	Grupo Aliperti – Siderúrgica J. L. Aliperti S.A.	24	Brazil
67.	SLC Agrícola S.A.	01	Brazil
68.	Terra Santa Agro S.A.	01	Brazil
69.	Biosev S.A.	01	Brazil
70.	Raízen S.A.	01	Brazil
71.	São Martinho S.A.	10	Brazil
72.	Camil Alimentos S.A.	10	Brazil
73.	Conservas Oderich S.A.	10	Brazil
74.	J. Macedo S.A.	10	Brazil
75.	Josapar-Joaquim Oliveira S.A.	10	Brazil
76.	M.Dias Branco S.A. Indústria e Comércio de Alimentos	10	Brazil
77.	BRF Global S.A.	10	Brazil
78.	Excelsior Alimentos S.A.	10	Brazil
79.	JBS S.A.	10	Brazil
80.	Marfrig Global Foods S.A.	10	Brazil
81.	Minerva S.A.	10	Brazil
82.	Minupar Participações S.A.	10	Brazil
83.	Ambev S.A.	11	Brazil
84.	Bombril S.A.	20	Brazil
85.	Natura Cosméticos S.A.	21	Brazil
86.	Metalgráfica Iguacu S.A.	22	Brazil
87.	Duratex S.A.	16	Brazil
88.	Eucatex S.A.	16	Brazil
89.	Cia Melhoramentos de São Paulo	02	Brazil

Appendix A – Summary of firms by firm name, ISIC rev. 4 and country (Continue)

N	Firm name	2-digit ISIC rev. 4	Country
90.	Irani Papel e Embalagem S.A.	17	Brazil
91.	Klabin S.A.	17	Brazil
92.	Santher – Fábrica de Papel Santa Therezinha S.A.	17	Brazil
93.	Suzano S.A.	17	Brazil
94.	Sansuy S.A. Indústria de Plásticos	22	Brazil
95.	Fertilizantes Heringer S.A.	20	Brazil
96.	Nutriplant Indústria e Comércio S.A.	20	Brazil
97.	Braskem S.A.	20	Brazil
98.	GPC Participações S.A.	20	Brazil
99.	Tronox Pigmentos do Brasil S.A.	20	Brazil
100.	Unipar Carbocloro S.A.	20	Brazil
101.	Paranapanema S.A.	24	Brazil
102.	Mangels Industrial S.A.	24	Brazil
103.	Panatlântica S.A.	24	Brazil
104.	Tekno S.A.	24	Brazil
105.	Cia Ferro Ligas da Bahia – Ferbasa	24	Brazil
106.	Cia Siderúrgica Nacional – CSN	24	Brazil
107.	Gerdau S.A.	24	Brazil
108.	Metalúrgica Gerdau S.A.	24	Brazil
109.	Usiminas S.A.	24	Brazil
110.	Vale S.A.	07	Brazil
111.	Lupatech S.A.	06	Brazil
112.	OSX Brasil S.A.	06	Brazil
113.	Petro Rio S.A.	06	Brazil
114.	Petrobras S.A.	06	Brazil
115.	Refinaria de Petróleos Manguinhos S.A.	06	Brazil
116.	Ultrapar Participações S.A.	06	Brazil
117.	Baumer S.A.	32	Brazil
118.	Biomm S.A.	21	Brazil
119.	Hypera Pharma S.A.	21	Brazil
120.	Nortec Química S.A.	21	Brazil
121.	Profarma Distribuidora produtos farmacêuticos S.A.	21	Brazil
122.	Positivo Tecnologia S.A.	26	Brazil
123.	Cielo S.A.	62	Brazil
124.	Linx S.A.	62	Brazil
125.	Quality Software S.A.	62	Brazil
126.	SINQIA S.A.	62	Brazil
127.	TOTVS S.A.	62	Brazil
128.	Agrosuper S.A.	10	Chile
129.	AntarChile S.A.	02	Chile
130.	Asenav Astilleros Y Servicios Navales S.A.	30	Chile
131.	Blumar Seafoods S.A.	03	Chile
132.	Cia Pesquera Camanchaca S.A.	03	Chile
133.	CAP S.A.	07	Chile
134.	Carozzi Corp S.A.	10	Chile
135.	Arauco S.A.	02	Chile

Appendix A – Summary of firms by firm name, ISIC rev. 4 and country (Continue)

N	Firm name	2-digit ISIC rev. 4	Country
136.	CEM S.A.	07	Chile
137.	Cemento Polpaico S.A.	23	Chile
138.	Cementos Bío Bío S.A.	23	Chile
139.	CINTAC S.A.	25	Chile
140.	Coagra S.A.	03	Chile
141.	Coca-Cola Embonor S.A.	11	Chile
142.	Compañia de Cervecerías Unidas – CCU S.A.	11	Chile
143.	Compañia Chilena de Fósforos S.A.	20	Chile
144.	Compañia Electro Metalurgica S.A.	24	Chile
145.	Compañia Industrial El Volcan S.A.	23	Chile
146.	Compania Maritima Chilena – CMC S.A.	50	Chile
147.	Compañias CIC S.A.	31	Chile
148.	Corporacion Nacional del Cobre de Chile CODELCO S.A.	07	Chile
149.	Cristalerias de Chile S.A.	23	Chile
150.	Embotelladora Andina S.A.	23	Chile
151.	Empresa Nacional de Aeronautica de Chile ENAER S.A.	30	Chile
152.	Empresa Nacional de Telecomunicaciones S.A.	61	Chile
153.	Empresa Nacional del Petroleo – ENAP S.A.	06	Chile
154.	Empresa Pesquera Eperva S.A.	03	Chile
155.	Empresas CMPC S.A.	49	Chile
156.	Empresas IANSA S.A.	10	Chile
157.	ENAEX S.A.	20	Chile
158.	Envases del Pacifico – EDELPA S.A.	23	Chile
159.	Essbio S.A.	36	Chile
160.	Frutícola Viconto S.A.	01	Chile
161.	Grupo Empresas Navieras – GEN S.A.	50	Chile
162.	Infodema S.A.	16	Chile
163.	Intasa S.A.	24	Chile
164.	IPAL S.A.	10	Chile
165.	Masisa S.A.	16	Chile
166.	Matriz SAAM S.A.	50	Chile
167.	Melón S.A.	23	Chile
168.	Minera Valparaiso S.A.	07	Chile
169.	Molibdenos y Metales – MOLYMET S.A.	20	Chile
170.	Muelles de Penco S.A.	52	Chile
171.	Multiexport Foods S.A.	10	Chile
172.	Nibsa S.A.	25	Chile
173.	Quiñenco S.A.	11 & 27 & 19	Chile
174.	Schwager Energy S.A.	07	Chile
175.	Sigdo Koppers S.A.	07 & 20 & 23 & 43	Chile
176.	Sociedad Agricola la Rosa Sofruco S.A.	01	Chile
177.	Viña Santa Rita S.A.	11	Chile
178.	Sociedad Nacional de Oleoductos – SONACOL S.A.	49	Chile
179.	Sociedad Procesadora de Leche del Sur S.A.	11	Chile
180.	Sociedad Punta del Cobre – PUCOBRE S.A.	07	Chile
181.	Sociedad Quimica y Minera de Chile – SQM S.A.	20	Chile

Appendix A – Summary of firms by firm name, ISIC rev. 4 and country (Continue)

N	Firm name	2-digit ISIC rev. 4	Country
182.	SODIMAC S.A.	23	Chile
183.	Soprocal Calerías y Industrias – SOPROCAL S.A.	20	Chile
184.	Soquimich Comercial – SQMC S.A.	20	Chile
185.	Telefónica Móviles Chile S.A. – ICR Chile	61	Chile
186.	Tricot S.A.	14	Chile
187.	Viña Concha y Toro S.A.	11	Chile
188.	Viña Los Vascos S.A.	11	Chile
189.	Viñedos Emiliana S.A.	11	Chile
190.	Watts S.A.B. de C.V.	10	Chile
191.	Alfa Group S.A.B. de C.V.	06 & 11 &19 & 28	Mexico
192.	Grupo Carso S.A.B. de C.V.	23 & 28 & 43 & 61	Mexico
193.	Grupo Industrial Saltillo – GIS S.A.B. de C.V.	23 & 28 & 43	Mexico
194.	Grupo Mexicano de Desarrollo (GMD) S.A.B. de C.V.	43	Mexico
195.	Grupo Sanborns S.A.B. de C.V.	32 & 46	Mexico
196.	Kuo Automotriz S.A.B. de C.V.	10 & 20 & 28	Mexico
197.	Mexichem S.A.B. de C.V.	20	Mexico
198.	Promotora Ambiental S.A.B. de C.V.	38	Mexico
199.	Grupo Rotoplas S.A.B. de C.V.	25	Mexico
200.	Arca Continental S.A.B. de C.V.	23	Mexico
201.	Coca-Cola FEMSA S.A.B. de C.V.	11	Mexico
202.	Fomento Económico Mexicano S.A.B. de C.V.	11	Mexico
203.	Gruma S.A.B. de C.V.	10	Mexico
204.	Grupo Bafar S.A.B. de C.V.	10	Mexico
205.	Grupo Bimbo S.A.B. de C.V.	10	Mexico
206.	Grupo Comercial Chedraui S.A.B. de C.V.	10	Mexico
207.	Grupo Gigante S.A.B. de C.V.	10 & 23 & 46	Mexico
208.	Grupo Herdez S.A.B. de C.V.	10	Mexico
209.	Grupo Lala S.A.B. de C.V.	10	Mexico
210.	Industrias Bachoco S.A.B. de C.V.	01	Mexico
211.	Genomma Lab Internacional S.A.B. de C.V.	21	Mexico
212.	Alpek S.A.B. de C.V.	20	Mexico
213.	Altos Hornos de Mexico – AHMSA S.A.B. de C.V.	24	Mexico
214.	Cementos y Concretos Moctezuma S.A.B. de C.V.	23	Mexico
215.	Cemex S.A.B. de C.V.	23	Mexico
216.	Convertidora Industrial S.A.B. de C.V.	22	Mexico
217.	Elementia S.A.B. de C.V.	23	Mexico
218.	Grupo Cementos de Chihuahua – GCC S.A.B. de C.V.	23	Mexico
219.	Grupo Lamosa S.A.B. de C.V.	23	Mexico
220.	Grupo Pochteca S.A.B. de C.V.	20	Mexico
221.	Grupo Simec S.A.B. de C.V.	20	Mexico
222.	Industrias CH S.A.B. de C.V.	24	Mexico
223.	Industrias Peñoles S.A.B. de C.V.	07	Mexico
224.	Interceramic S.A.B. de C.V.	23	Mexico
225.	Proteak Uno S.A.B. de C.V.	02	Mexico
226.	America Móvil S.A.B. de C.V.	61	Mexico
227.	Axtel S.A.B. de C.V.	61	Mexico

Appendix A – Summary of firms by firm name, ISIC rev. 4 and country (Continue)

N	Firm name	2-digit ISIC rev. 4	Country
228.	Maxcom Telecomunicaciones S.A.B. de C.V.	61	Mexico
229.	Aceros del Peru S.A.C.	25	Peru
230.	Agroindustrias – AIB S.A.	01	Peru
231.	Alicorp S.A.	20	Peru
232.	Austral Group S.A.A.	03	Peru
233.	Cementos Pacasmayo S.A.A.	23	Peru
234.	Cerveceria San Juan S.A.	11	Peru
235.	Compañía de Minas Buenaventura S.A.A.	07	Peru
236.	Compañía Minera Poderosa S.A.	07	Peru
237.	Compañía Minera San Ignacio de Morococha S.A.A.	07	Peru
238.	Compañía Minera Santa Luisa S.A.	07	Peru
239.	Compañía Universal Textil S.A.	13	Peru
240.	Consorcio Industrial de Arequipa – CIDASA S.A.	14	Peru
241.	Corporacion Ceramica S.A.	23	Peru
242.	Creditex S.A.A.	01	Peru
243.	Empresa Editora el Comercio S.A.	61	Peru
244.	Empresa Siderurgica del Peru – SIDER Perú S.A.A.	24	Peru
245.	EXSA S.A.	20	Peru
246.	Fabrica Nacional de Acumuladores ETNA S.A.	62	Peru
247.	Fabrica Peruana Eternit S.A.	23	Peru
248.	Hidrostal S.A.	28	Peru
249.	Indeco S.A.	27	Peru
250.	Industrias del Envase S.A.	23	Peru
251.	Industrias Electro Quimicas – IEQSA S.A.	20	Peru
252.	Laive S.A.	10	Peru
253.	Leche Gloria S.A.	10	Peru
254.	Lima Caucho S.A.	28	Peru
255.	Lindley Corporatión S.A.C.	23	Peru
256.	Medrock Corporatión	21	Peru
257.	Michell y Cía S.A.	15	Peru
258.	Minsur S.A.	07	Peru
259.	Motores Diesel Andinos – Modasa S.A.	30	Peru
260.	Nexa Resources Atacocha S.A.A.	07	Peru
261.	Perubar S.A.	07	Peru
262.	Pesquera Exalmar S.A.	03	Peru
263.	Petroleos del Perú – PETROPERU	06	Peru
264.	Quimpac S.A.	20	Peru
265.	Manufactura de Metales y Aluminio Record S.A.	24	Peru
266.	Refineria la Pampilla – REPSOL PE S.A.A.	06	Peru
267.	Shougang Hierro Perú S.A.A	07	Peru
268.	Sociedad Minera Cerro Verde S.A.A	07	Peru
269.	Sociedad Minera Corona – Minera Corona S.A.	07	Peru
270.	Sociedad Minera el Brocal S.A.A	07	Peru
271.	Southern Peru Copper Corporation – SPCC	07	Peru
272.	Unión Andina de Cementos – UNACEM S.A.	23	Peru
273.	Union de Cervecerias Peruanas Backus y Johnston S.A.A	11	Peru

Appendix A – Summary of firms by firm name, ISIC rev. 4 and country (Conclusion)

N	Firm name	2-digit ISIC rev. 4	Country
274.	Volcan Compañia Minera S.A.A	70	Peru
275.	Yura S.A.	23	Peru