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Faculty of Business Economics

Master of Management

Master's thesis

Innovation and internationalization: role of cooperation, based on patent analytics. Country of study: Chile

Raul Cortes
Miette Larravide

Thesis presented in fulfillment of the requirements for the degree of Master of Management, specialization Strategy and Innovation Management

SUPERVISOR :
Prof. dr. Mark VANCAUTEREN

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2019
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This Master Thesis was written during the COVID-19 crisis in 2020. This global health crisis might have had an impact on the (writing) process, the research activities and the research results that are at the basis of this thesis

ACKNOWLEDGEMENTS

I wish to acknowledge the support and great love of my parents, my father: Nemesio Raúl; and my mother: Maria Elisa. Also I would like to pay my special regards to my research partner: Miette Larravide and last but not least to my supervisor: Prof. dr. Mark Vancauteren for inspiring my interest in the analysis of internationalization of innovation.

Raúl Cortés

The outcoming result of this study couldn't have been achieved in this period without the collaboration of my team partner Raul Cortes, so many thanks.

Also, big thanks to my supportive family, mostly my parents, Ximena and Carlos, who have always supported me in every idea that comes to my mind, even been far away.

Lastly, I cant stop thanking my partner, Alejandro, who has being by my side all the way in this study year, motivating me constantly.

As to an end, deeply thanks Prof. dr. Mark Vancauteren, our lecturer, who has always been available for us, providing all the tools and guidance needed to finish the study.

Miette Larravide

EXECUTIVE SUMMARY

Research Purpose: The globalization of firms has contributed to pressure them to become more innovative and to conduct R&D activities on a global scale, leading to an increase in both domestic and international collaborative research (Faria & Schmidt, 2012). The patent information on inventors can be used to understand how the invention process is internationalized, by examining whether inventors or applicants resident in different nations are involved in one patent, that is, whether an international cooperation is involved (Nagaoka et al., 2010). Therefore, the aim of the study is to realize how Chile is performing regarding the innovation, internationalization and cooperation compared to Colombia, Finland and Czech Republic, based in the study of SHIA, SHAI and SHII indicators from patents. It is in the interest of this study to perform a wider comparison of South America versus Europe and to illustrate heterogeneity across countries with these measurements.

Research Questions: a) Which is the position of Chile regarding the internationalization of technological innovation among the region and Europe? b) Are there any correlations between R&D factors and the internationalization of innovation, applicable to both regions?

The research will be descriptive. The information required to develop the study will be collected from open national patent files, to then be analyzed and finally describe the results. The method therefore will be quantitative, as data collection is numerical and it involves counting and quantitative comparisons (Kamil, 2004).

Findings: First Question: Chile allocates more resources of their GDP for R&D activities than Colombia, and this point is absolutely important for answering the question, because in order to have a significant internationalization of innovation is essential to have a minimum floor of it. Unfortunately, due to little spending efforts involved in the region, the advantage in the gap between the two countries is trivial. Secondly, and going straight to the indicators of internationalization, Chile presents in some cases a better overall SHIA; SHAI; SHII indicators than Colombia. But, the values of the indicators showed little consistency, and much variability between years, making the predictability of these values unquestionable challenging for the future, and making the measure of the internationalization undoubtedly problematic as well.

Second Question: Regarding the comparison with Europe, Chile is tremendously below in terms of the percentages of GDP resources allocated for R&D. Additionally, Europe presented a greater coherence of the indicators throughout the years of this study. It was not possible to identify factors that promote internationalization that are applicable to both regions. In the case of Europe (Finland and Czech Republic) it was possible to find correlations between the factors and the internationalization of innovation. On the contrary, in South America, no correlations were detected. It will be a challenge for Chile, in the future, to reduce this variability in order to become more like leading innovation economies.

All things considered, leads to the conclusion that in South America, and specifically in Chile, the low amounts of investment in R&D, the high variability of indicators and the absence of

correlations are a reflection of a lack of a country long-term vision about the importance of innovation for the development of the countries and the region. As recommendations for firms inside Chile, would be to open up their businesses, invest more in R&D, associate with partners (start-ups, research institutes, universities, etc.) locally and internationally. In the case of multinationals, promote cooperation between different branches, encourage research and development within the region, support the movement of employees between countries. Additionally, to promote through partnerships the creation of a node of sensing networks (global networks of innovation) in the region. Currently these innovation hotspots are found mostly in California, the east coast of the USA, Europe and China, but since South America has enough highly skilled human capital, multinational companies could start looking this region and try to gradually position this part of the world in that direction. In a nutshell, go towards a vision of regional development, which in the long run will be more beneficial for all South American countries. It is no possible yet to compare Chile to highly developed economies members of the OECD, but the country must take into account their examples in order to reach a sustainable economic growth, and so be able to reduce poverty and inequalities.

Value of the Study: To look for the existence of common drivers of cooperation applicable to both regions (South America & Europe). The purpose then is to provide a big picture of how Chile is and where it should be regarding the international cooperation of innovation. It's estimated it was possible to get to a valuable input of the current situation of Chile, in addition to demonstrate the importance of the role of cooperation as a booster for innovation, and the role of innovation as a booster for economic growth, providing a constant source of competitive advantages[1]. The study offers some suggestions estimated to be keys to create concrete solutions. Understand and embrace the value of innovation and international collaboration to achieve economic growth is a need for a better future in Chile, and consequently for a better living of its population.

Critical Considerations: Research Limitations: Generally, not all new applications of knowledge are patented and not all patents are equally significant. This situation represents the mayor issue when analyzing internationalization of innovation with patent files. Additionally, patents also represent practical applications of specific ideas rather than more general concepts or advances in knowledge (OECD, 1996). So, as the study is based on patents analytics, it is important to highlight these limitations of measuring innovation through patent data. Future Research: The reasons for the historical lack of cooperation in South America cannot be explained exclusively due to economic factors but also for social and cultural reasons that this study cannot cover. Therefore, future investigation with researchers from other disciplines may cover the social and cultural motives involved.

[1] The bases of competitive advantage are superior resources and organizational capabilities from the value chain. In order to keep a sustained competitive advantage, the resource or capability must be Valuable, Rare, Inimitable and Organized.

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ABSTRACT

As global competition intensifies, it's hard to survive by being autonomous, as resources needed are not always among a firm or a country's boundaries, but outside of them. The role of cooperation with external parties has become essential to boost creativity which ends in innovative solutions, to reduce costs and times of developing new products/services, to enhance firm's and countries' global competition, to acknowledge customer needs to penetrate new markets, among other benefits. Therefore, this study focuses on Chile's position in this matter compared to Colombia, Finland and Czech Republic. Likewise, as patent information has been increasingly used to analyze innovation, the indicators SHIA SHAI and SHII, proposed by Guellec & van Pottelsberghe de la Potterie, were selected to carry out the investigation. After finalizing, it's got come to the conclusion that the country needs to invest considerably more of its GDP in R&D activities and involve a steadier international cooperation, in order to impulse the creation of competitive advantages[2] and therefore its economic growth.

ABSTRACTO

A medida que se intensifica la competencia global, es difícil sobrevivir siendo autónomo, ya que los recursos necesarios no siempre se encuentran dentro de las fronteras de una empresa o de un país, sino fuera de ellas. La cooperación con partes externas se ha vuelto esencial para impulsar la creatividad, que desencadena en soluciones innovadoras, para reducir los costos y tiempos de desarrollo de nuevos productos/servicios, para mejorar la competencia global de las empresas y los países, para reconocer las necesidades de los clientes al penetrar nuevos mercados, entre otros beneficios. Por lo tanto, este estudio se centra en la posición de Chile en este asunto en comparación con Colombia, Finlandia y la República Checa. Debido a que la información sobre patentes se ha estado utilizando cada vez más para analizar la innovación, los indicadores SHIA SHAI y SHII, propuestos por Guellec y van Pottelsberghe de la Potterie, fueron seleccionados para llevar a cabo la investigación. Después de finalizar, se llegó a la conclusión de que el país necesita invertir considerablemente más de su PIB en actividades de I&D e involucrar una cooperación internacional más estable, para impulsar la creación de ventajas competitivas y, por lo tanto, su crecimiento económico.

Key words: Innovation, internationalization, cooperation, R&D, patents.
Palabras clave: Innovación, internacionalización, cooperación, I&D, patentes

[2] The bases of competitive advantage are superior resources and organizational capabilities from the value chain. In order to keep a sustained competitive advantage, the resource or capability must be Valuable, Rare, Inimitable and Organized.

INTRODUCTION

Technological innovations have become more and more important for a country's economic growth and competitiveness in the period of global knowledge economy (Guan & Chen, 2012).

In today's competitive markets, intellectual assets are increasingly developed and used by companies as a key factor to economic success (Munari & Oriani, 2011). Globalization has brought many benefits for economy but also big challenges for companies. Product-life cycles are shorter, and firms need keep up with the competition to survive by bringing innovative products or services to the market. Therefore, innovation performance, the capability to innovate and to bring innovation successfully to market, is a crucial determinant of competitiveness and national progress (OECD, 2007). This has led companies to increasingly open their innovation processes and collaborating on innovation with external partners (from suppliers to customers and research institutes), facing a demand for knowledge that they usually cannot satisfy within their internal resources and capabilities alone. So, the internationalization of research and development (R&D) and innovative activities have become an important component of the ongoing trend towards globalization of the economy (Guellec & van Pottelsberghe de la Potterie, 2001).

The focus of this study is first to investigate the position of Chile, regarding the internationalization of innovation, in relation to Europe and South America. The countries selected for the investigation (besides Chile) were Finland, Czech Republic and Colombia, all of them members of the OECD and all with similar economy sizes (in terms of the GDP). Secondly, to analyze the possible existence of factors, applicable to both regions, that facilitate the development of this internationalization.

The tools that will be used to carry out this study will be three indicators given by patents: SHIA, SHAI and SHII proposed by Guellec & van Pottelsberghe de la Potterie. In addition, the linear regression method will be used to analyze the possible correlation between the different factors. The information required will be collected from patents as inventions in the countries.

A. LITERATURE REVIEW

1. Knowledge: Driver of Productivity and Economic Growth

It has long been recognized that "economic prosperity rests upon knowledge and its useful application". Indeed, the "increase in the stock of useful knowledge and the extension of its application are the essence of modern economic growth" (Teece, 2003). It is to say, knowledge is now recognized as the driver of productivity and economic growth, leading a new focus on the role of information, technology and learning in economic performance. Knowledge creation thus becomes the most relevant means to generate profits and growth in living standards (Munari & Oriani, 2011). So, the term "knowledge-based economy" stems from the fuller recognition of the place of knowledge and technology in modern OECD economies (OECD, 1996). It is important for the study to mention that the shift towards a knowledge-based economy has enhanced patent relevance for firm's strategic decisions and economic performance (Munari & Oriani, 2011).

1.1. Role of Innovation in Knowledge and Growth

As mentioned before, knowledge-based economy is the one for which defined economic growth is based on the creation, distribution, and use of technology embodies in physical and human capital. Fundamentally, innovation policy in such an economy must enrich the creation, distribution, and use of knowledge that leads to the creation, distribution, and use of the technology (Feldman & Link, 2001).

What is innovation?

Innovation can be understood as a process in which organizations actively create and develop new knowledge to solve problems, for the purpose of using them in the economy. The process of innovation is a rhythm of exploration, selection, synthesis, and cycles of divergent thinking followed by convergence. Innovation development is a very uncertain process, in which entrepreneurs undertake a sequence of events over a long period of time to transform a new idea into a product, service or process. Undoubtedly, innovation depends upon the individual, group and organizational knowledge, skills and capabilities (Bueno & Ordóñez de Pablos, 2004).

Today, investment, innovation performance, the capability to innovate and to bring innovation successfully to market, is a crucial determinant of competitiveness and national progress. There is growing awareness among policymakers that innovative activity is the main driver of economic progress and well-being as well as a potential factor in meeting global challenges in domains such as the environment and health (OECD, 2007).

The knowledge economy is a dominant force in today's world, and innovation policy and national systems of innovation are central to it (Bullen et al., 2006). The centre-stage role of

intellectual property rights, mainly patents, within the innovation strategy of the firm, can be interpreted as the principles of the Knowledge-based Economy (Munari & Oriani, 2011).

2. Internationalization of Innovation: Driving Forces for Firms

At a high level of generality, the internationalization of innovation means that inventions, inventors, and the ownership of these inventions tend to cross national borders more frequently. Technology invented in one country can be put in use in another country. Scientists and engineers born in one country graduate and get a job in another country, while possibly returning back to their home country after a while. Firms located in different countries set up alliances for research and development (Guellec & van Pottelsberghe de la Potterie, 2001). In other words, internationalization can be defined as expanding across country borders into geographic locations (e.g., markets) that are new to the firm (Hitt et al., 1994).

The driving forces of the internationalization of innovation, over firms, are mainly two: 'demand-oriented' factors which denote the circumstances and deliberations inducing companies to locate R&D abroad in order to better serve foreign national markets and 'supply-oriented' factors which refer to characteristics in the local foreign environment that enhance the efficiency of R&D by providing e.g. favorable access to skilled technical expertise, perhaps at lower cost than available elsewhere, access to foreign universities and other research establishments, and so on (Granstrand et al., 1993). In fewer words, a) to penetrate foreign markets by adapting their products and processes to local conditions and b) to take advantage of foreign expertise (Gerybadze et al., 2010).

a) To penetrate new markets companies must adapt their products to regional needs or even develop special products, as preferences in demand vary from country to country. The need to adapt products to address the special demands of international customers often leads companies to invest in R&D abroad. Additional foreign research benefits the company at home to the extent that it serves the purpose of expanding in foreign markets (Gerybadze et al., 2010).

b) Companies are better able to acquire new technical expertise from research institutions and universities when they are in close proximity geographically to one another. In order to absorb existing knowledge in foreign countries, companies must be embedded in local research networks with their own research departments. The opportunity to tap the know-how of scientific and technical experts in foreign countries is an important motivation for conducting R&D activities abroad. (Gerybadze et al., 2010)

To develop the analysis of internationalization of innovation, this study will mainly focus on point b), as it is the role of cooperation among inventors from different countries what will be measured (through patents as inventions).

2.1. What does it mean to the Firm? To a Country?

If technological innovation is the most important force driving economic growth in the long run, then public policies designed to promote and encourage technological innovation take on substantial importance (Branstetter & Sakakibara, 2002).

Governments nowadays must invest in R&D in order to realize economic, social, environmental and cultural benefits for the community it represents. As such, the justification for public investment in R&D should be subject to scrutiny and review as with all other areas of public decision making (Piric & Reeve, 1999). Governments today search for effective compositions of technology policy instruments, such as fiscal measures, credits or subsidies which are most promising for future growth. Governments in the world emphasize the need to improve the transfer of know-how throughout the innovation system. One of the main issues in this context is collaboration between science and industry to strengthen the national innovation capabilities. (Czarnitzki & Fier, 2003).

All over the OECD countries business strategies for R&D and innovation have evolved significantly in industry and governments during the past few decades, for example. Considerable evidence indicates an increasing number of R&D co-operations, mergers, patent licenses and alliances in industry and science. Innovation policy shifted from the focus on big science carried out by large companies only to a general trend towards R&D networking and intensified efforts to strengthen domestic firms, technologies and competencies (Czarnitzki et al., 2007). Innovation policy rests on several pillars: direct subsidies for research projects within thematic programs and promotion of SMEs in three promotion lines (innovation, co-operation, technology consulting), and by four types of support (grants, loans, venture capital and infrastructure supply). In general, firms can compose an individual mix of public support from of the different pillars that suit their specific challenges best (Czarnitzki et al., 2007).

It has been claimed that companies that operate in many countries learn from different innovation contexts and are, therefore, able to benefit from them. The sources of learning and knowledge acquisition can be many (Filippetti et al., 2009).

So, regarding all mentioned above, if a country is highly internationalized it is likely to have a higher innovation performance because:

- Its resources (labor, management etc.)
- Its products and its institutions are exposed to alternative innovation contexts, and this allows firms and people to learn from different environments
- More competition forces the firms to innovate (Filippetti et al., 2009).

"Taking collective responsibility for a strategic, inclusive and business-oriented research and innovation policy, to tackle major societal challenges, raise competitiveness and generate new jobs"(European Commission, 2010).

2.2. Relationship between Internationalization of Innovation and Economic Performance

Economic-growth theorists and management scholars have proposed that innovation has a positive impact on corporate performance. That is, increasing investments in innovation allows firms to develop and license new technologies, adopt more efficient production techniques, introduce new products and processes, and consequently become more competitive and increase their economic performance. However, past empirical results are mixed, not always confirming this theoretical proposition. Hence, even though a number of studies have evaluated the relationship between innovation and performance, it is often unclear why some firms benefit from their innovative efforts, yet others fail to do so (Kafouros et al., 2008). Nevertheless, there are theoretical arguments and research results to support a positive relationship between international diversification and firm performance (Hitt et al., 1994). It is suggested that firms need some threshold of internationalization and to be able to access a broad range of markets in order to benefit sufficiently from their new products and processes (Kafouros et al., 2008).

International diversification is also positively related to firm innovation. Expansion into international markets provides opportunities for greater returns on innovations and reduces the risk of failure due to the additional number of markets in which the innovation may be applied. Furthermore, innovation facilitates higher performance in internationally diversified firms because successful innovation provides a continuing source of competitive advantage[3]. International diversification provides potential for firms to achieve greater returns on innovations (larger and/ or a greater number of markets with different demand characteristics) and thus, lowers the risks of R&D investments. As a result, international diversification provides incentives for firms to innovate and thus, leads to more innovation (Hitt et al., 1994).

Firms realized that without internationalization, they can no longer maintain their market shares. Internationalization is also their response to the threats of globalization and a way of firms to adapt to the challenges they face with it. The internationalization of firms from transition economies was only a few year ago considered an "exotic" activity, yet it is now gaining in importance under the pressures of globalization (Jaklič & Svetličič, 2003).

3. Different Types of Innovation: General Overview

It is possible to find in literature many ways of classifying innovation and there are many existing criteria for it, but mostly, almost all on innovation classifications are linked to product innovations. There are two very used categories:

[3] The bases of competitive advantage are superior resources and organizational capabilities from the value chain. In order to keep a sustained competitive advantage, the resource or capability must be Valuable, Rare, Inimitable and Organized.

a) Radical Innovation: These are discontinuous events and in recent times is usually the result of a deliberate research and development activity in enterprises and/or in university and government laboratories. They are unevenly distributed over sectors and over time (Coccia, 2017). Radical innovations represent fundamental changes that represent revolutionary changes in technology. (Dewar & Dutton, 1986).

b) Incremental Innovation: These occur more or less continuously in any industry or service activity, although at a varying rate in different industries and over different time periods. They may often occur, not so much as the result of formal research and development activity, but as the outcome of inventions and improvements suggested by engineers and others directly engaged in the production process, or as a result of initiatives and proposals by users (Coccia, 2017). Incremental innovation are minor improvements or simple adjustments in current technology (Dewar & Dutton, 1986). For example, take the form of changing the materials used to make a product, improving the product through an updated design, or adding additional features or options (Rowley et al., 2011).

The major difference captured by the labels radical and incremental is the degree of novel technological process content embodied in the innovation and hence, the degree of new knowledge embedded in the innovation (Dewar & Dutton, 1986).

3.1. Intellectual Property Protection: Patents

The term "patent" stands for an exclusive right granted by the State in order to protect an invention, from which all other persons, so long as the grant runs, are excluded. By statute this right involves the right to make, use and sell (Hamilton & Tilli, 1945), getting this way a monopoly over an invention for a period of usually 20 years. In addition to patents, there are two other ways to protect intellectual property that companies can use for their innovations, these being Trade Secrets and Strategic Disclosure. As follows, the focus will be on patents since they are of public knowledge and therefore useful for this study. It is important to remember that not all innovations will be protected through patents, some of them may go to one of the other mechanisms mentioned before.

Patents, also known as patents of invention, are the most widespread existing means of protecting inventor's rights. A patent gives to its owner the exclusive right of denying third parties to commercially exploit the protected invention for a certain period of time, in exchange of revealing the invention to the public. Therefore, the proprietary of the patent can prevent that others make, use, sell or import the invention with no permission, and can sue anyone who exploits the invention without his permission (*¿Qué Son Las Patentes? - INAPI. Institucional*, n.d.). By establishing a proprietary market advantage, the right of exclusion granted by patents allows firms to reward R&D efforts and to focus on complementary activities

(for example branding) that are meant to sustain the products once they have been launched in the market (Munari & Oriani, 2011).

As the infringement of copying patented innovation is costly, the patent system thereby promotes an effective level of innovation by providing incentives to inventors to invent, market and sell innovative products, and to disclose the knowledge underlying those innovations in the form of published patents documents (Graham & Sichelman, 2008).

Amongst a variety of intellectual assets, patents have displayed a significant potential as a source of revenue and as means to improve the competitive position of leader firms and to be on the forefront of innovation. Traditionally firms have fiercely protected and exclusively relied upon their own patents in facing the blurring of industry boundaries and the increasingly global competition (Munari & Oriani, 2011).The theory in which the system is based is that the financial benefits coming from the patent exploitation and the revelation of the resultant inventions for its diffusion and public use, will promote innovation and will rise the technical level on a country's industry, with obvious benefits for its trade (*¿Qué Son Las Patentes? - INAPI. Institucional*, n.d.).

In addition, patent systems remain predominantly national institutions with a small number of regional arrangements, which means in order to patent inventions, in a worldwide scope, it is necessary to fill applications on each of the countries involved (Drahos, 2010).

Table N°1: Advantages and Disadvantages of Patenting

Main Advantages	Main Disadvantages
Technology protection: In order to protect assets and market share.	Offensive use: patents can be used as a strategic offensive tool, either as a competitive weapon or as an economic asset.
Licensing out: As a result, companies have become more technological dependent upon each other, allowing to spread knowledge across industries and get an economic benefit.	
Cross-licensing: Allows to access technology through cross-licensing.	
Cooperative R&D: having patents can be beneficial for firms in order to identify, attract and negotiate with R&D partners.	

(Granstrand, 2000)

4. How to measure Internationalization of Innovation

Knowledge transmission mechanisms can be many and involve relationships between customers and sellers, principal and contractors, academic research networks, or employees working for the various institutions or moving between different employers. These mechanisms operate at both the national and international levels (Filippetti et al., 2011).

The benefits of R&D are much more evenly distributed in the world than the expenditures on R&D; this evidence suggests that technology diffuses internationally. The interesting issue for researchers is how technology diffuses across national borders and what is the magnitude of the diffusion. There are several indicators that can be named to measure internationalization of innovation. Now, there are two leading candidates for diffusion channels, which are international trade and foreign direct investment (FDI) (Xu & Wang, 2000).

Trade: International trade in technology has grown rapidly, becoming significant in comparison with national expenditures for R&D in developed economies. Technological knowledge provides demand-side economies because knowledge can be transferred at relatively low cost and applied by multiple users. International trade in technology allows multiple countries to combine R&D efforts and to employ the same innovation. Countries achieve gains from trade by transferring knowledge. International trade in technology improves the quality of innovation, by enlarging the pool of R&D experiments from which the best technology is chosen and by stimulating the entry of inventors (Spulber, 2008).

Exports encourage/force firms to innovate by exposing them to stronger competition as well as to the requirements and innovation environment of diverse markets and customers (Ietto-Gillies, 2013).

Imports bring additional competition and variety to domestic markets, benefiting consumers, while exports enlarge markets for domestic production, benefiting businesses.

Trade exposes domestic firms to the best practices of foreign firms and to the demands of discerning customers, encouraging greater efficiency. Trade gives firms access to improved capital inputs such as machine tools, boosting productivity and providing new opportunities for growth for developing countries (Schneider, 2005).

A firm may first test a foreign market via exports. After an initial trial period, it will stop exporting to that market, if it discovers that it cannot make enough profits to cover the trade costs. For intermediate levels of realized profitability, it will continue exporting without engaging in FDI. For higher levels of profitability, it will establish foreign affiliates (Conconi et al., 2016).

FDI: Foreign direct investment takes place when a corporation in one country establishes a business operation in another country, through setting up a new wholly-owned affiliate, or acquiring a local company, or forming a joint venture in the host economy (Moran, 2012). FDI inflows are viewed as a measure of the extent to which a country or a region is integrating into the world economy (Pournarakis & Varsakelis, 2004).

There's also another important factor of internationalization of innovation that involves the mobility students. In the contemporary era, interpreted as an age of 'the knowledge economy', High Education (HE) has become an indicator of economic competitiveness, and the internationalization of HE is often regarded as an innovative response to external marketing opportunities. Nowadays, the academic marketplace' is becoming increasingly transnational under the influence of economic globalization. In other words, the internationalization of HE has been taken as a strategy in the mire of increasing global economic competition in many countries, with the emphasis on trade in HE and the world university rankings, and the international recruitment of the best and brightest students and scholars (Kim, 2009).

Having said that, the measure of internationalization of innovation can be done from two perspectives: a firm level approach and a country level approach. In this study it was selected to carry out an analysis from a country level. The indicators used are derived from information available in patent data proposed by Guellec & van Pottelsberghe de la Potterie. These indicators are SHIA, SHAI and SHII which will be explained in point 4.2.

Now, why indicators from patents?

Patent information is increasingly used to analyze innovation and the innovation process, and patent statistics are increasingly used as a measure of innovation. Actually, patents have been the only source of rich information on new technology, which is screened in a systematic manner by using a considerable amount of resources by governments over a long period of time (Nagaoka et al., 2010).
Patents represent ideas themselves and therefore are the closest to direct indicators of knowledge formation; the traditional knowledge from patents, most directly measure knowledge outputs (rather than inputs). Also, patents data have certain advantages in that most countries have national patent systems organized on centralized databases, the data cover almost all technological fields, and patent documents contain a large amount of information concerning the invention, technology, inventor, etc. (OECD, 1996).

In most cases, the information of patents includes the inventor's name and address, the applicant's name and address, dates such as the priority date, application date and grant date, and technology classes, usually based on International Patent Classification (IPC) (see Appendix 1a). It can also include the references to patents and non-patent documents such as academic papers. This bibliographic information enables the possibility to research on innovation (Nagaoka et al., 2010).

Table N°2: IPC Classification:

SECTION	DESCRIPTION
A	Human Necessities
B	Performing Operations; Transporting
C	Chemistry; Metallurgy
D	Textiles; Paper
E	Fixed Constructions
F	Mechanical Engineering; Lighting; Heating, Weapons; Blasting
G	Physics
H	Electricity

The patent information on inventors can be used to understand how the invention process is internationalized, by examining whether inventors or applicants resident in different nations are involved in one patent, that is, whether an international cooperation is involved (Nagaoka et al., 2010) (see Appendix 1b).

4.1. International Cooperation of Innovation

As global competition intensifies and innovation becomes riskier and more costly, the business sector has been internationalizing knowledge-intensive corporate functions, including R&D. At the same time, companies are increasingly opening their innovation processes and collaborating on innovation with external partners (suppliers, customers, universities, etc.) (OECD, 2008).

Open Innovation, defined by Chesbrough (2003), is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology. Open Innovation combines internal and external ideas into architectures and systems whose requirements are defined by a business model. An open Business model then, create value by leveraging many more ideas, due to their inclusion of a variety of external concepts. Open models can also enable greater value capture, by using a key asset, resource, or position not only in the company's own business but also in other companies' businesses (H. Chesbrough, 2006).

Now, when it comes to patent an invention and that single patent is fully owned by two or more innovators it's called a joint patenting, also known as co-patenting. An innovator could be an individual, academic establishment, research institution, government entity, firm or the like (Briggs & Wade, 2014). When cross-border ownership of inventions happen, is when at least one inventor and the applicant reside in different countries. It is deemed to reflect the location of R&D activities of multinational firms. For most EPO (European Patent Office) patents (a share usually estimated to be higher than 90%), the applicant is an institution (a firm, a university, a public laboratory). The inventor is always an individual, usually a researcher employed by the applicant. Most often, the address of the inventor is the address of the

laboratory he/she works in. Then, when the inventor and the applicant of a patent do not reside in the same country, this reflects in a huge majority of cases the fact that the patent protects an invention performed in a research facility abroad of a multinational firm (Guellec & van Pottelsberghe de la Potterie, 2001).

Firms today, driven by more complex innovation projects and ever shorter innovation and product- life cycles, are faced with a demand for knowledge they cannot satisfy with their internal resources alone. The globalization of firms' activities has contributed to the pressure to become more innovative and to conduct R&D and innovation activities on a global scale, leading to an increase in both domestic and international collaborative activities (Faria & Schmidt, 2012).

So, according for what was mentioned above, cooperation has become an important organizational component of the innovation process. In recent years increasing numbers of firms have become involved in collaborative relationships with a variety of partners, from suppliers to customers and research institutes (Aschhoff & Schmidt, 2008).

As found in literature and as OECD (2008) mentions, one of the main drivers for cross-border (international) R&D cooperation is the need to complement expertise to obtain access to different technologies and knowledge quickly, as global competition and technological progress is more intense today. Product life cycles have been drastically shortened forcing companies to innovate faster and develop products and services more efficiently. Moreover, the growing integration of different technologies has made innovation more costly and riskier. The greater the need for interdisciplinary cross-border and cross-sector research, the less a single company has the capability to innovate successfully. So, besides obtaining needed knowledge faster, collaboration also helps to diminish costs. Globalization require companies to be open to external ideas that supplement internal R&D in order to remain competitive (OECD, 2008).

4.2. Study Approach: SHIA, SHAI and SHII as Indicators of Internationalization of Innovation

As mentioned before, patents are one of the most effective mechanism that companies have to protect their new technologies and innovation assets, for the economic development. Therefore, patents are a great source of key indicators of technological innovation.

SHIA, SHAI and SHII were the indicators, proposed by Guellec y Van Pottelsberghe de la Potterie (2001), selected for measuring the internationalization of technological innovation through patents (meaning the world spreading of inventions, people behind the inventions and owners of the inventions). These indicators allow to compare the internationalization of different countries and regions, providing a visual representation with clear and easy to understand relations among the different elements. It counts with 2 dimensions, patent information and country level:

- The information available from the patents files provides key data for this calculation, such as inventor, applicant, countries of residence and the International Patent Classification (IPC).
- The country level approach is extensive and offers a suitable picture since all patents are given a similar treatment, allowing to compare different countries with consistency, utilizing the same nature of inputs regardless the cultural differences among geographical zones. Additionally, countries boundaries are generally stable across short periods of time, just like the one applied for this study.

For this reason, SHIA, SHAI and SHII provide valuable outputs for analyzing the internationalization of innovation, allowing to compare among countries with consistency, utilizing open and standardized national patent files (free to dispose and available for the majority of the countries in the world).

(Guellec & van Pottelsberghe de la Potterie, 2001)

5. Limitations in the Analysis of Patent Files and Indicators

Patents in particular have become more and more important for companies' activities, profits and competition (Munari & Oriani, 2011). Multinational companies need to patent their inventions around the world in order to protect their assets.

There are several ways to analyze patent data, including categorizing patents by geographic area and industrial product group, as the SHIA/SHAI/SHII indicators explained above. However, a few differences in national patenting systems introduce a despicable bias, which can be dealt, not making comparisons difficult. In contrast, it is essential to mention one critical obstacle: generally, not all new applications of knowledge are patented and not all patents are equally significant. This situation represents the mayor issue when analyzing internationalization of innovation with patent files. Additionally, patents also represent practical applications of specific ideas rather than more general concepts or advances in knowledge (OECD, 1996).

Moreover, there is one last concern derived by using the country level approach. In this analysis is not possible to differentiate some issues of the internationalization, such as the relation of this internationalization with corporate strategies, which could be identified utilizing a company level approach instead, with indicators like R&D abroad of multinational firms. So, as patents do not represent the total innovation of a country or region, and for other issues in utilizing the data mentioned before (among others), these do not provide a 100% truth image. Nevertheless, it has great advantages such as the broad availability and the international comparability. That being said, patents offer the best and most reliable source, for what the study desires to achieve, and should provide a highly valuable big picture of the current situation.

B. PROBLEM STATEMENT

Nowadays, as it has been mentioned before, innovation enables restructuration and productivity, and therefore, economic growth. Additionally, the internationalization of R&D and innovative activities has become an important component of the ongoing trend towards globalization of the economy. Firms collaborate and acquire technological knowledge outside their organizational boundaries to reduce innovation costs, to decrease time to bring innovations into the market and/or leap-frog existing technologies (Czarnitzki & Fier, 2003). Also, cooperation between parties enhance and boosts creativity and helps to bring new solutions to people's needs, solving problems.

This ongoing phenomenon makes it interesting to wonder if similar behaviors and approaches are happening in developed and developing countries. Most top economies (if not all) allocate high investments in research and development, and take the collaboration as a necessity of the globalized world, but what about developing and underdeveloped countries?

The aim of the investigation thus, is to realize how Chile is performing regarding the innovation, internationalization and cooperation compared to other countries, based in the study of SHIA, SHAI and SHII indicators given by patent data.

The selected countries for the study (besides Chile) were Colombia, Finland and Czech Republic, as it will be interesting to perform a wider comparison of South America versus Europe, to illustrate heterogeneity across countries with these measurements, so to reveal plausible underlying explanation, and because of data availability provided by these countries. All four countries are member of the OECD (Colombia's admission was announced on April 28th, 2020), plus all of them have similar size economies magnitudes in term of GDP.

6. Research Objective

First, to identify how technologically internationalized is Chile compared with other European and South American countries members of OECD.

Second, to identify if there is any correlation between R&D factors and the internationalization of innovation, applicable to both regions.

6.1. Research Questions

1) Which is the position of Chile regarding the internationalization of technological innovation among the region and Europe?

2) Are there any correlations between R&D factors and the internationalization of innovation, applicable to both regions?

7. Type of Investigation

The research will be descriptive. According to Glass & Hopkins (1984), descriptive research involves gathering data that describe events and then organizes, tabulates, depicts, and describes the data collection. The information required to develop the study will be collected from data bases of registered patents of each evaluated country, to then describe the results. The method therefore will be quantitative, were the emphasis is on counting and measuring, that is to say, the research is using measures that are quantifiable in numeric terms. Data collection is numerical and it involves counting and quantitative comparisons (Kamil, 2004).

C. SITUATION OF SELECTED COUNTRIES: EUROPEAN VERSUS SOUTH AMERICAN CONTEXT

South American View: Through Chile & Colombia

Latin American and Caribbean countries have exhibited a very modest rate of economic growth during the past decade, despite unusually favorable economic conditions. Latin America's poor economic performance can be understood by examining the rate of R&D expenses over the GDP of the region compared with other regions of the world. This indicator shows that the OECD's decade-average during 1960–2000 fluctuated between 1.87 percent and 2.25 percent. In the case of Scandinavian countries, the R&D effort increased from 1.12 percent in the 1960s to 2.71 percent in the 1990s. In contrast, R&D expenditure in Latin America fluctuated between 0.36 percent and 0.52 percent of GDP during the same period (Alvarez et al., 2010).

To better understand, GDP spending on R&D is defined as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country. It includes R&D funded from abroad, but excludes domestic funds for R&D performed outside the domestic economy (*OECD*, 2020).

Chile has been one of the fastest growing economies in South America in recent decades, which has allowed the country to significantly reduce poverty. On May 7, 2010, Chile became the first South American country to join the Organization for Economic Cooperation and Development (OECD). However, more than 30% of the population is economically vulnerable and income inequality remains high (The World Bank, 2020). The very high share of low-skilled workers, gaps in infrastructure and low investment in innovation and R&D hinder productivity and are associated with a persistent dependence of exports on mostly natural resources, notably copper, agriculture and fisheries, and low-technology manufactures ("OECD Economic Surveys: Chile," 2018).

According to José Miguel Benavente (2004), considering the level of economic development of Chile, there are serious deficiencies in the National System of Innovation. The country has very low resources designated to R&D as a proportion of GDP, very few scientific workforce and professionals dedicated to research activities, as well as a scare participation (involvement) of the private sector in financing these activities. Expenditure on R&D is low as a share of GDP, especially in the business sector. ("OECD Economic Surveys: Chile," 2018).

To compare Chile with another country from the South American region, it was chosen Colombia. The parameters to choose this country were: because of their similar economy size in terms of GDP, because both countries experience similar issues in terms of innovation, because of data availability and because the admission of Colombia to the OECD was recently announced this year (April 28th, 2020).

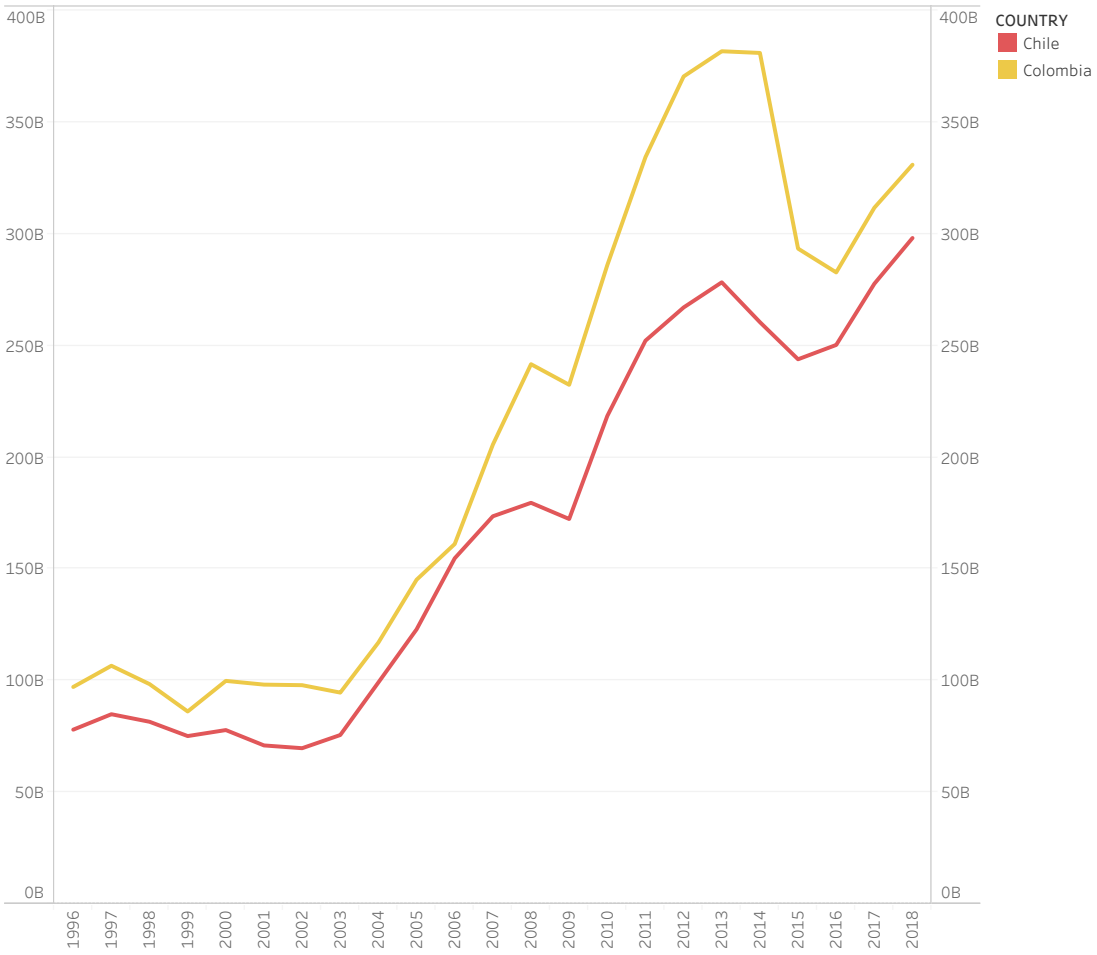
Table N°3: 2018 GDP (current US$) – Chile & Colombia

COUNTRY	VALUE (MILLION)
Chile	298,231
Colombia	331,047

Own creation, Source: The World Bank

In table Nº3, it is possible to appreciate the similar magnitudes on the GDP of both South American countries.

Graphic N°1: GDP (current US$) – Chile & Colombia



Own creation, Source: The World Bank

In graphic N°1 is possible to observe the GDP increase of Colombia (in yellow) and Chile (in red) from 1996 until 2018. Colombia is above Chile in terms of GDP, but both present similar varieties among the years. (see Appendix 3 to observe the GDP and the R&D/GDP ratio, of both countries, between 1996 and 2017).

Nowadays, Chile and Colombia face the challenge of achieving equitable and sustainable economic development. In order to initiate a process of long-term growth, they need to ensure

that they are ready to exploit the unlimited potential coming from innovation and technological progress, and that their investment both in the quality of human capital and in improving the institutional framework is directed respectively towards increasing learning capacity and vitalizing the country's innovation system (Marotta et al., 2007).

In Chile and Colombia (Latin America and the Caribbean region in general), there is evidence of what has been defined an "innovation failure" or deficiency of innovation. Many indicators show weaknesses in the capacity of Latin American firms to innovate and commercialize research in recent years and there is no indication of an inversion of this trend (Marotta et al., 2007).

One of the weakness indicators in the capacity of private firms to innovate and commercialize research is given by the discrepancy between R&D expenditures in the private and public sectors. Comparing with OECD countries, it is possible to observe in the OECD, private firms finance two-thirds of the R&D expenses while in Chile the private sector finances only one-third of the R&D expenses. In Colombia the picture is similar, with only 7 out of 100 firms investing in R&D and a total of investments that reaches only 0.1% of GDP. According to a global survey of business executives, public-private collaboration in Chile and Colombia is rated respectively 3.2 and 3.5 on a 7-point scale. This is well below that in high-income countries, where the average rating is 4.1. The main obstacles to this collaboration seem to be lack of trust, different working cultures and different motives of collaboration (Marotta et al., 2007).

<u>European View: Through Finland & Czech Republic</u>

Knowledge and intellectual capital are major determinants of innovation and thus of enhancing the growth, employment and competitiveness of the European Union (Piekkola, 2011).

At the European Council in Lisbon in March 2000, heads of state and governments set the European Union the ambitious goal of becoming "the most competitive and dynamic knowledge-based economy in the world by the end of the decade". Two years later the Council reaffirmed this goal in Barcelona and added it to a more specific but equally ambitious target of raising EU spending on R&D to 3% of GDP by 2010 – with two thirds of this spend by the business sector. The stimulation of R&D cooperation and networks has become very popular in technology policies of the EU lately (Czarnitzki & Fier, 2003).

Regarding Finland, this country has enjoyed strong economic progress over the past decades, which is reflected in high living standards and well-being. The country stands out for high subjective well-being, education and skills, environmental quality and personal security. Productivity has fallen in manufacturing and has hardly increased in business services. Rising labor costs and a loss of non-cost advantages have eroded international competitiveness. The government program to streamline regulations, promote competition and encourage entrepreneurship will support growth. Collaboration on innovation of both large firms and Small and Medium Enterprises (SMEs) with higher education or research institutions is among the strongest in the OECD. Team Finland has been created to coordinate the activities of several

institutions, with a focus on internationalization. Planned cuts in funding risk weakening the innovation and entrepreneurship potential of Finland. The government program includes cuts on funding for innovation, and initiatives to attract more venture capital. About inequality in Finland, is among the lowest in the OECD and has stayed fairly constant since the turn of the century, following a sharp increase in the 1990s. The ratios of high and median to low incomes show similar patterns. Absolute poverty, measured as material and housing deprivation, is among the lowest in the EU. With a relatively compressed wage distribution, the main drivers of income are employment and productivity ("OECD Economic Surveys: Finland," 2016).

On the external side, the Czech economy is particularly exposed to trade disruptions. Exports in terms of value added contribute to around 45% of GDP. The Czech Republic's growth model of low wage and high reliance on FDI has been successful in increasing GDP per capita but convergence towards OECD living standards is slow. Even though wages have accelerated recently, their level remains low in international comparison. Low labor shares are influenced by the gap between GDP per capita and gross national income, which is among the highest in OECD countries. FDI have benefited the economy through its increasing participation in global value chains. However, there is room to better share the benefits of growth to support inclusive development ("OECD Economic Surveys: Czech Republic," 2018).

To choose two European countries and compare them with Chile, it was also taken into account the size of the economy in terms of GDP, data availability and for being members of the OECD. The most similar nations in these criteria were Finland and Czech Republic. Even though Finland has a higher rate of GDP/R&D, both are considered in an upright position among the Europe Union and they don't face as much trouble as Colombia and Chile in this aspect.

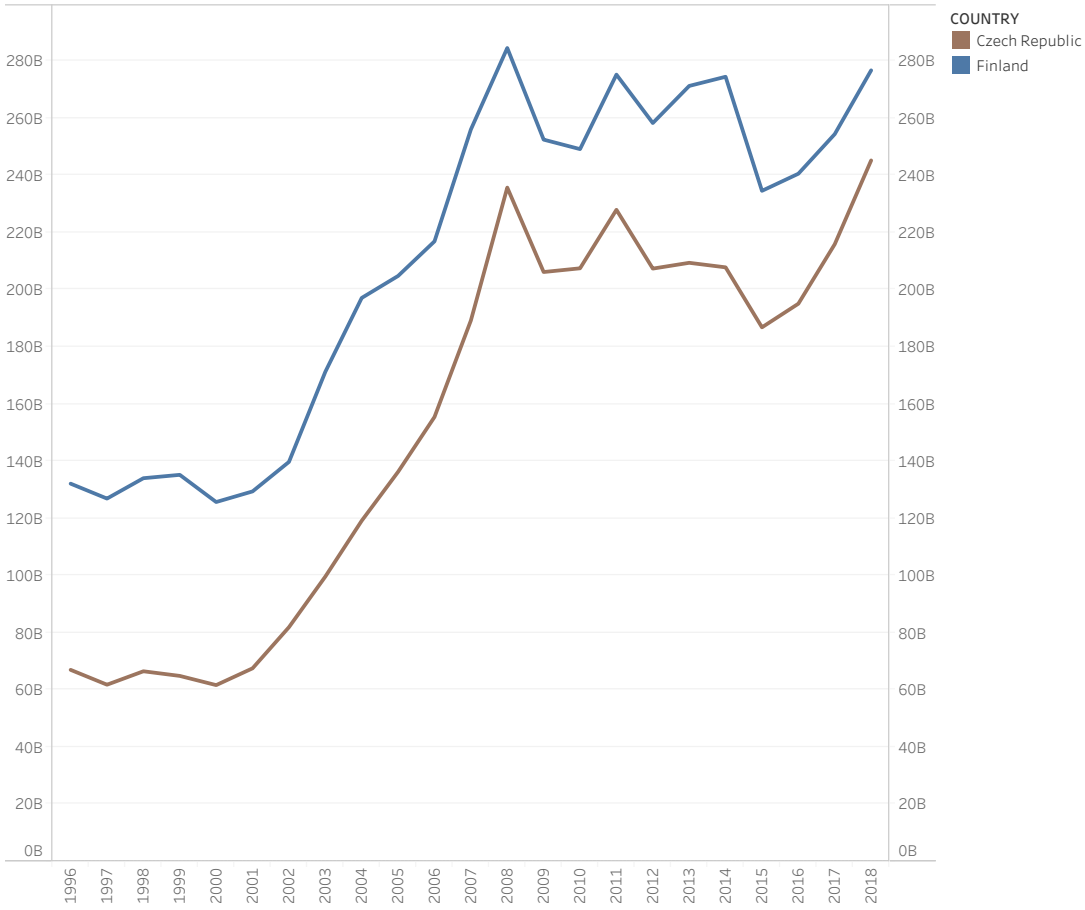
Table N°4: 2018 GDP (current US$) – Finland & Czech Republic

COUNTRY	VALUE (MILLION)
Czech Republic	245,225
Finland	276,743

Own creation, Source: (World Bank Group)

In table Nº4, it is possible to appreciate the similar magnitudes on the GDP of both European countries.

Graphic N°2: GDP (current US$) – Finland & Czech Republic



Own creation, Source: The World Bank

In the graphic N°2 it is shown the behavior of the GDP of Czech Republic (brown) and Finland between 1996 and 2018. Finland is above Czech Republic in terms of GDP, but both present similar varieties among the years. (see Appendix 3 to observe the GDP and the R&D/GDP ratio, of both countries, between 1996 and 2017)

D. MODEL DEFINITION

Variables

There are different ways that allow to give a perspective of internationalization of innovation in countries. In this study, the resources that will be used for the analysis are patents, and the indicators, as mentioned before, will be through SHIA, SHAI and SHII.

SHIA is the share of patents with at least one domestic inventor and a foreign applicant in the country's total domestic inventions. Can be seeing as a reflection of to which extension foreign firms control domestic inventions in a country *i*.

$$SHIA_i = \frac{PF_i^{IA}}{PFI_i}$$

PF_i^{IA}: It's the total number of patents invented by the residents of country *i* and controlled by foreign applicants.

PFI_i : It's the total number of patents invented by residents of a country i.

If the value of SHIA is 0, indicates that there are no patents with domestic inventors which owners are foreign residents. In the other hand, if the value of SHIA is 1, indicates that all of the patents with domestic inventors have foreign resident owners.

SHAI is the share of patents with at least one foreign inventor and a domestic applicant in the country's total domestic applications. Can be seeing as a reflection of to which extension domestic firms of a country *i* control foreign inventions.

$$SHAI_i = \frac{PF_i^{AI}}{PFA_i}$$

PF_i^{AI}: It's the number of patents invented by foreigner researchers and controlled by the residents of country *i*.

PFA_i : It's the total number of patents controlled by residents of a country *i*.

If the value of SHAI is 0, indicates that all of the patents in the study have domestic inventors. In the other hand, if the value of SHAI is 1, indicates that all of the patents in the study have foreign resident inventors.

SHII is the share for a given country of patents with a foreign resident as a co-inventor in the total number of patents with a domestic inventor. Can be seeing as the result from international research cooperation among domestic inventors of a country *i* and foreign residents, also can indicates the flow of knowledge between different countries.

$$SHII_i = \frac{P_i^{II}}{PI_i}$$

P_i^{II}: It's the number of patents invented by the residents of country *i* in collaboration with a foreign co-inventor.

PI_i : It's the total number of patents invented by residents of a country *i*.

(Guellec & van Pottelsberghe de la Potterie, 2001)

Methodology

To obtain the indicators of internationalization of technological innovation, the national database of patents from Chile, Colombia and the European Patent Office (EPO) through Espacenet[4] have been used. The patents information, downloaded on CSV format, covers the publication period of 2010 – 2019 and 84.486 publications. Since not all of the countries' files have the same format, all of them were standardized, in order to have clear availability of values such as dates, names and countries from inventors, co-inventors, applicants and IPC. Afterwards, this information has been analyzed using the data visualization software Tableau. Thanks to the use of logical functions and calculated fields, the SHIA, SHAI and SHII indicators have been parameterized and obtained for each of the scenarios of the study.

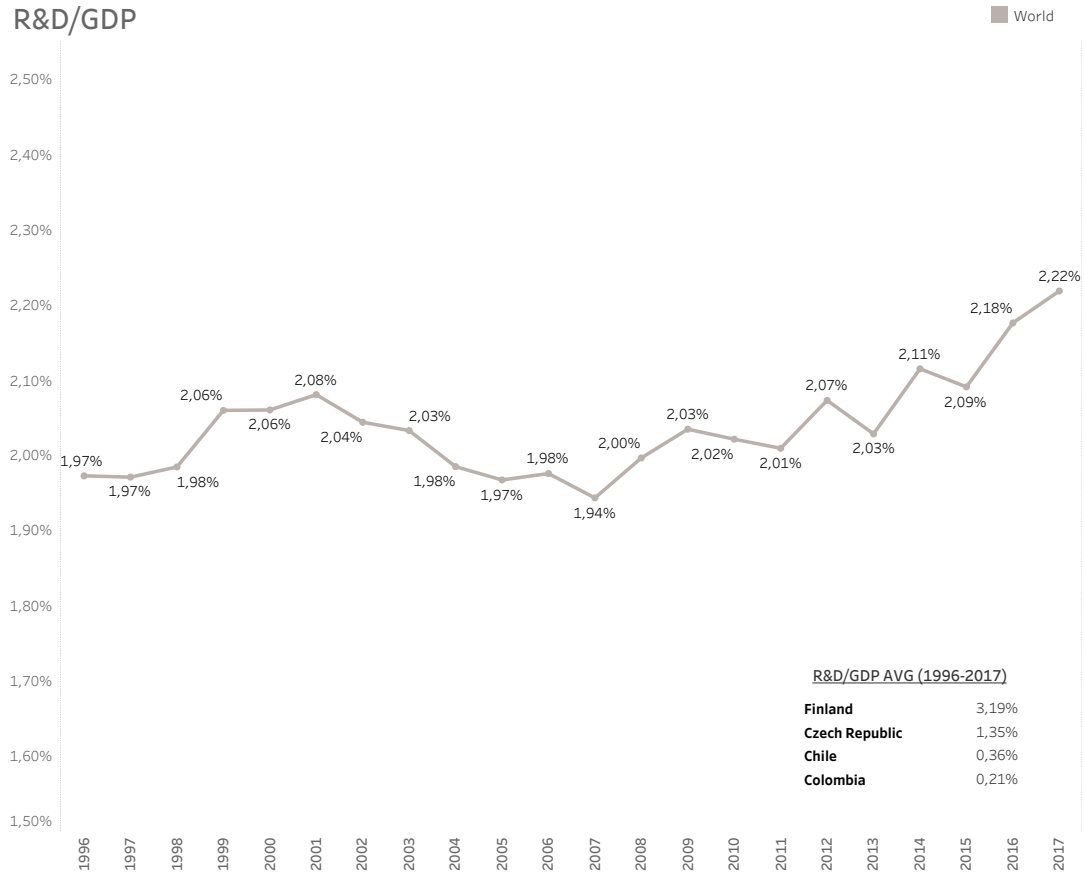
[4] Espacenet is a free online service for searching patents and patent applications. Espacenet was developed by the European Patent Office together with the member states of the European Patent Organization.

E. DATA DESCRIPTION

RESEARCH QUESTION N°1: What is the position of Chile regarding the internationalization of technological innovation among the region and Europe?

The following analysis will seek to answer the first research question, utilizing data and graphics from R&D/GDP, Number of publications, and SHIA; SHAI; SHII patent indicators. It covers a time period from 2014 to 2019 and 53.064 publications.

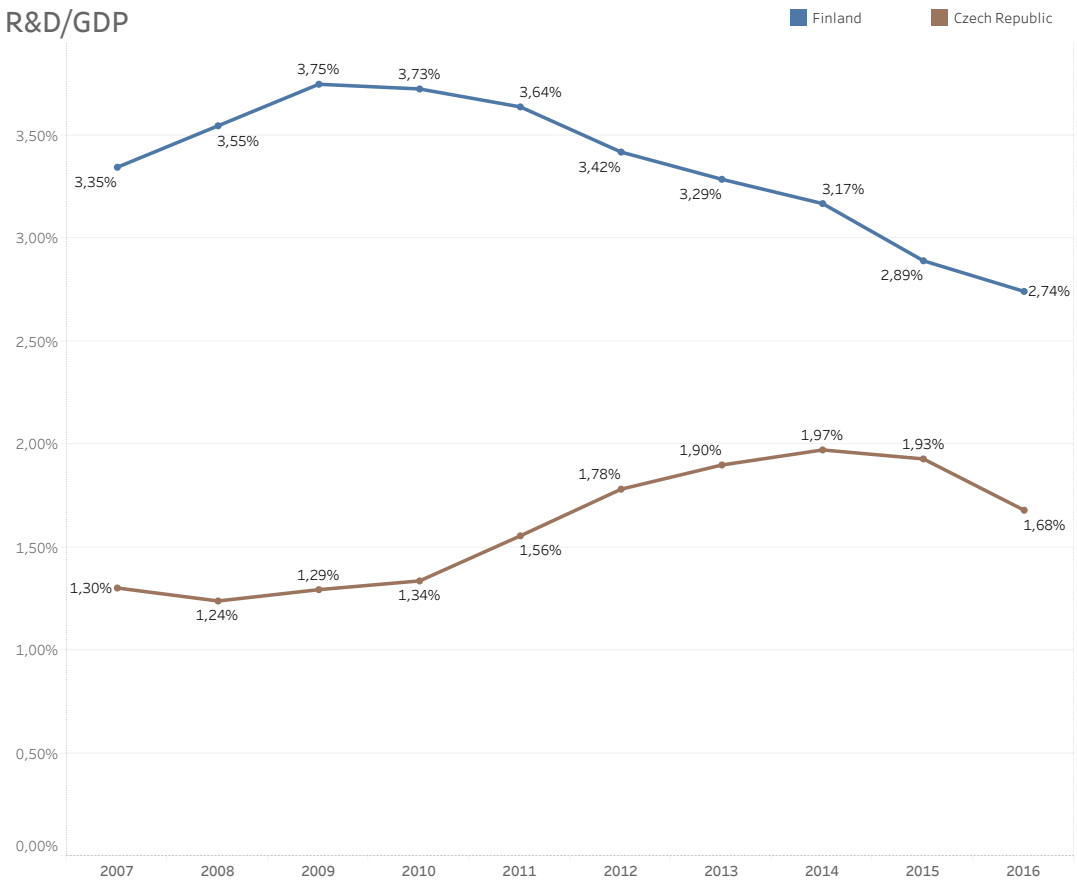
Graphic N°3: Rate of R&D spending on the GDP of the World



Own creation, Source: The World Bank

In the figure above, it is observed how the rate of R&D spending on the GDP of the World (considered as one economy) has grown in the last two decades. In addition, a table is presented with the average of this rate in the last 20 years for each of the 4 countries under the study, with Finland leading the proportionate expenditure, followed by the Czech Republic, then very low there is Chile and Colombia representing South America with a value that does not exceed 0.3% on average. (see Appendix 4 to observe the average of R&D/GDP, in the different countries of the World, between 1996 and 2017)

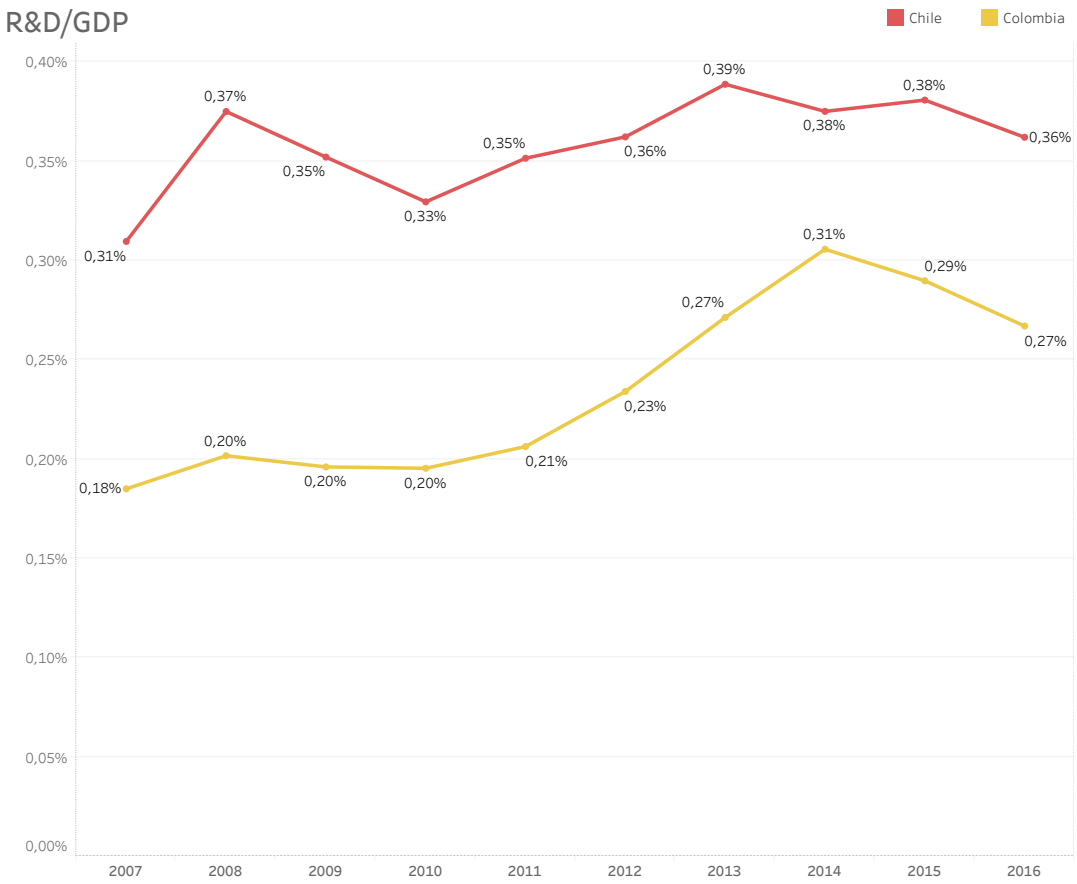
Graphic N°4: Rates of R&D spending on the GDP of Finland and Czech Republic



Own creation, Source: The World Bank

The figure above shows the rates of R&D spending on the GDP for Finland and Czech Republic in the last two decades. In the case of Finland, after 2009, this rate began to decrease, observing an important decrease of 1 percentage value from 3.75% in 2009 to 2.74% in 2016, being 2,74% still a high value (even superior to the World rate presented before). In the case of the Czech Republic, it is observed the opposite effect, in which a consistently increase in the rate is observed in the years 2011 to 2015, ending with a slight decrease in 2016, with a value of 1.68%, being below Finland but still a good value.

Graphic N°5: Rates of R&D spending on the GDP of Chile and Colombia



Own creation, Source: The World Bank

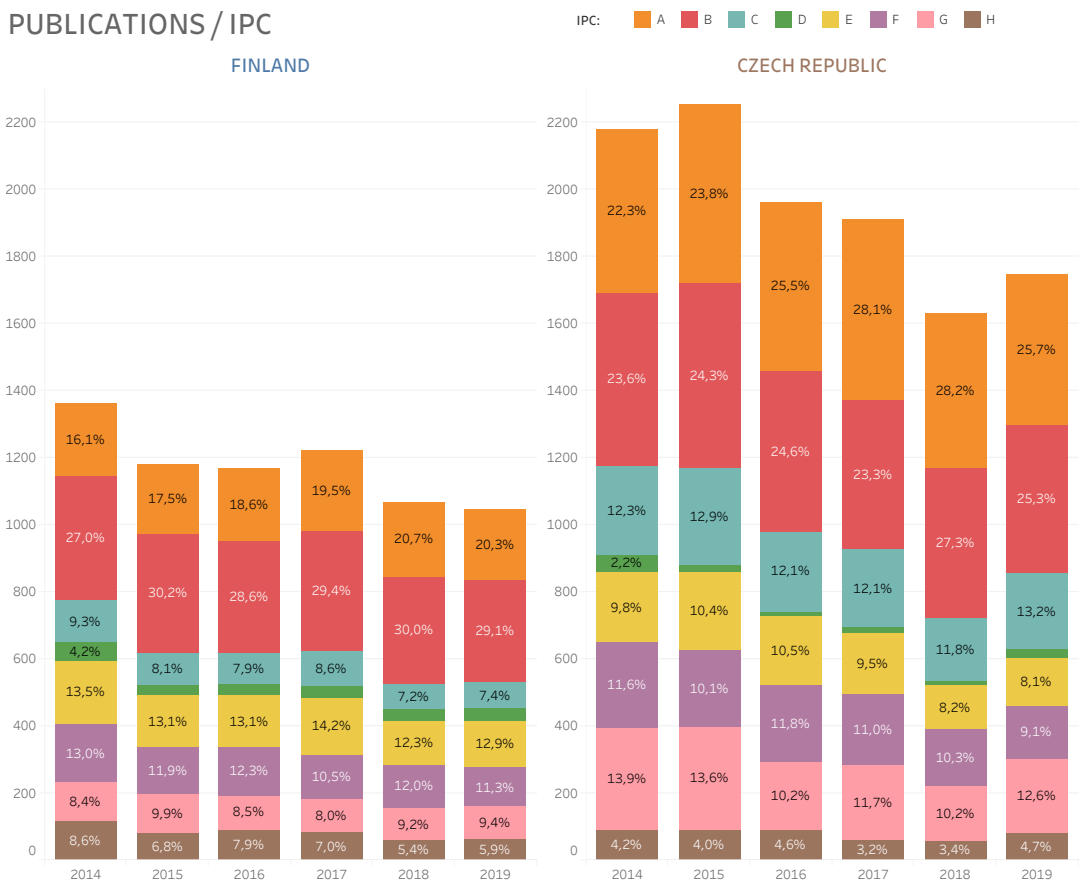
The figure above shows the rates of R&D spending on the GDP of Chile and Colombia in the last two decades. In the case of Chile, it is observed how basically the ratio maintains the same magnitude, ending 2016 with a value of 0,36%. In the case of Colombia, it is observed a slight increase of the rate in the years 2011 to 2014, ending with a minor decrease in 2016, with a value of 0,27%. In summary, even though Chile has higher values than Colombia, both countries allocate insignificant rates of R&D expenses over their GDP, being well below the numbers previously presented in Europe.

Graphic N°6: Average of R&D spending on the GDP for Finland & Czech and for Chile & Colombia

Own creation, Source: The World Bank

The figure above shows the rates of R&D spending on the GDP as an average for Finland and Czech and for Chile and Colombia, in the last two decades. The idea behind the graphic is to have a big picture of how much resources, those two different regions, allocate for R&D. The difference in values of both zones is tremendously explicit, being the two representatives of Europe close to 2,5% and being South America closer to zero.

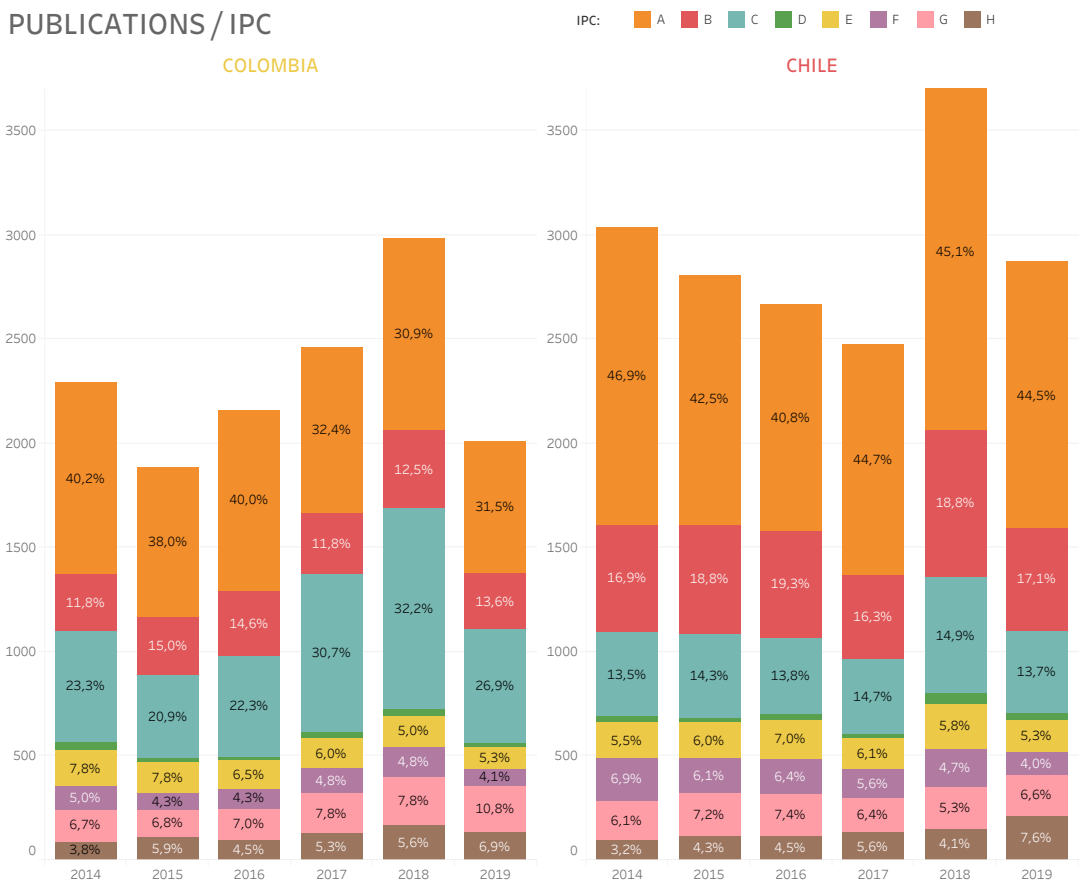
Graphic N°7: Patent Publications of Finland and Czech Republic



Own creation, Source: EPO Espacenet

Regarding patent publications of the two European members, it is observed both countries have decreased the amount of annual publications over the last six years, where Finland has considerably less publications than Czech Republic. In addition, it can be seen how in Finland the main IPC category of the annual publications is B, which are patents for PERFORMING OPERATIONS; TRANSPORTING, including the sub-categories of SEPARATING; MIXING, SHAPING, PRINTING, TRANSPORTING and MICROSTRUCTURAL TECHNOLOGY; NANOTECHNOLOGY. On the other hand, in Czech Republic the main categories of publications, besides B, is A, where the category A represent patents for HUMAN NECESSITIES, including the sub-categories of AGRICULTURE, FOODSTUFFS; TOBACCO, PERSONAL OR DOMESTIC ARTICLES and HEALTH; AMUSEMENT. (see Appendix 5a).

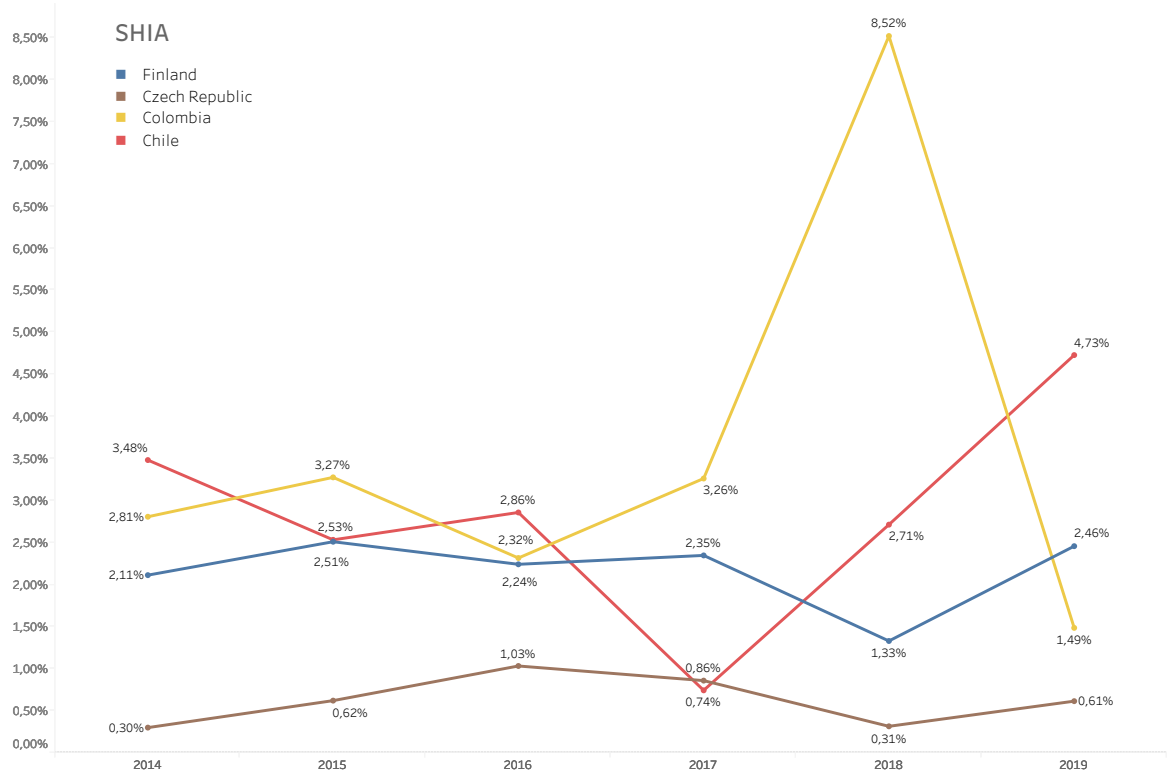
Graphic N°8: Patent Publications of Colombia and Chile



Own creation, Source: Colombia & Chile National patent database

Regarding patent publications of the two South America members, it is observed a similar amount of publications between both countries, but slightly higher for Chile. Now comparing to Finland and Czech Republic, it can be seeing how these European nations, in general, published less than the two South America members. Being A the main IPC category, which investigations fields relate to some of the natural resources, like AGRICULTURE, FOODSTUFFS; TOBACCO, PERSONAL OR DOMESTIC ARTICLES and HEALTH; AMUSEMENT. After observing these numbers, it can be reached a preliminary intuition that more is not always better with respect to the publication of patents and the internationalization of innovation. The explanation may be related to quality, scope, novelty, of the inventions published. (see Appendix 5b).

Graphic N°9: SHIA behavior in Finland, Czech Republic, Colombia and Chile

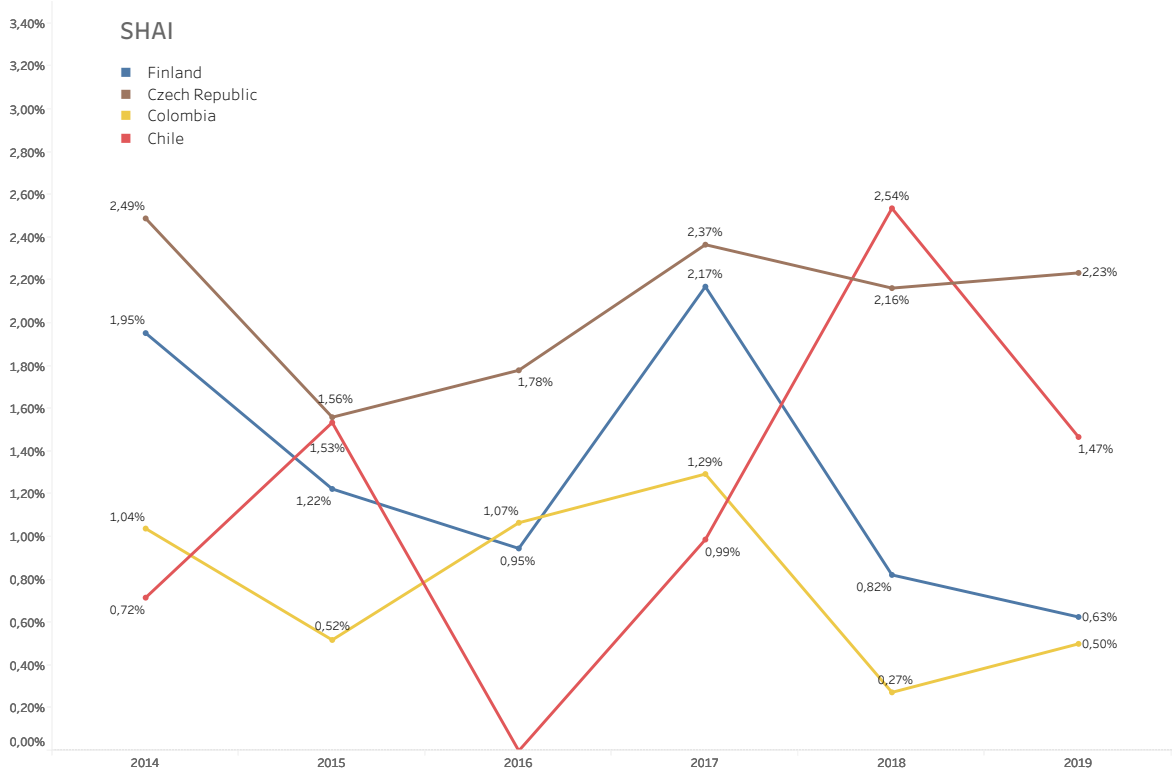


Own Creation, Source: EPO Espacenet and Colombia & Chile National patent database

As a reminder for the figure above, SHIA can be seeing as a reflection of to which extension foreign firms control domestic inventions. In the last six years this indicator has remained pretty constant in the two European countries. In the contrary, in the South American representatives, a less even and more random behavior is observed. For instance, Colombia presents an enormous peak in 2018 (the patent data reveals how this peak is due to a specific, one time, case of cooperation between a multinational applicant company based in Panama and Colombian inventors). Besides, the lower values of Czech Republic and Finland means more control over their own domestic inventions, than in South America.

(If the value of SHIA is 0, indicates that there are no patents with domestic inventors which owners are foreign residents. In the other hand, if the value of SHIA is 1, indicates that all of the patents with domestic inventors have foreign resident owners).

Graphic N°10: SHAI behavior in Finland, Czech Republic, Colombia and Chile

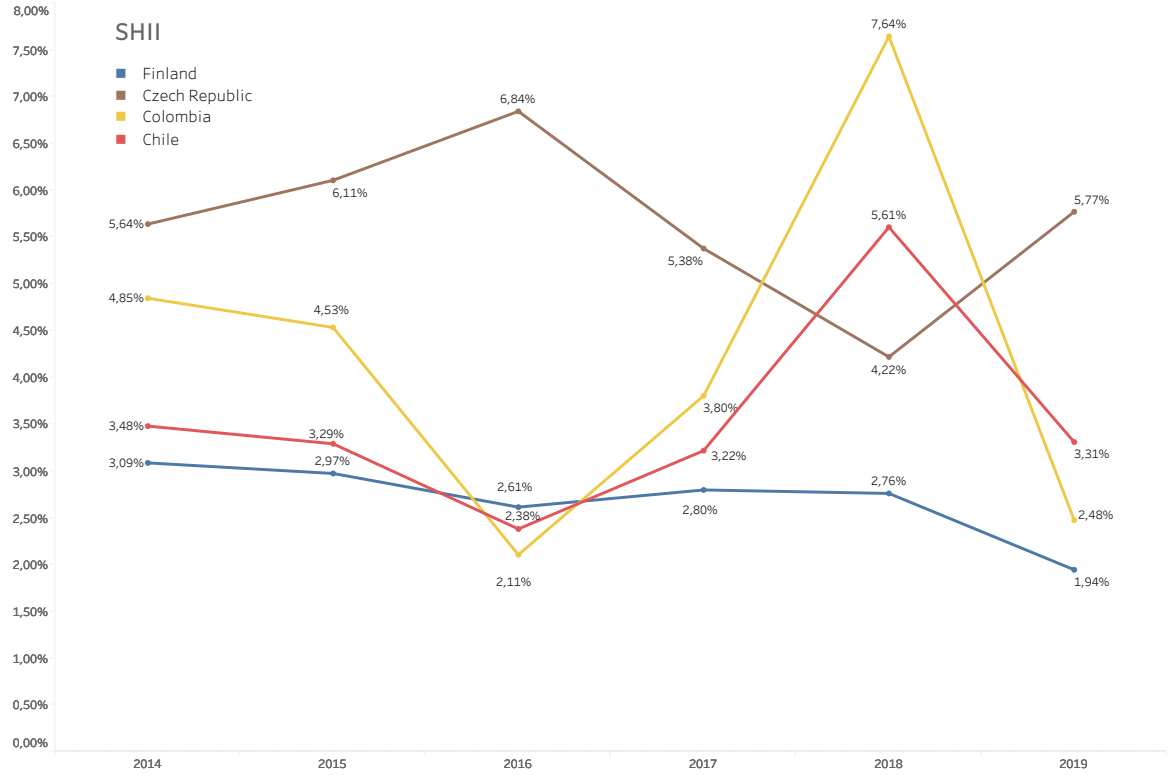


Own Creation, Source: EPO Espacenet and Colombia & Chile National patent database

As a reminder for the figure above, SHAI can be seeing as a reflection of to which extension domestic firms of a country are in control of foreign inventions. Overall, in the last five years this indicator has being higher for the two European countries. Again, a less even and more random behavior in South America can be observed, with a huge peak in Chile in 2018, and a zero value in 2016.

(If the value of SHAI is 0, indicates that all of the patents in the study have domestic inventors. In the other hand, if the value of SHAI is 1, indicates that all of the patents in the study have foreign resident inventors.)

Graphic N°11: SHII behavior in Finland, Czech Republic, Colombia and Chile



Own Creation, Source: EPO Espacenet and Colombia & Chile National patent database

As a reminder for the figure above, SHII can be seeing as the result from international research cooperation among domestic inventors and foreign residents. Also, it can indicate the flow of knowledge between different countries. Czech Republic leads in the cooperation of researchers, being above Finland for an important margin. This means, generally, in Finland researchers cooperate less with their international peers than the ones from Czech Republic. Again, the values of the representatives of South America are too variable, making hard to diagnose what the actual situation of both countries regarding this indicator is, some years they performed below Europe and other above it. In opposition Europe presents more consistency through time, specially the case of Finland. As a preliminary diagnosis, it can be intuited that this tremendous variability in the South American countries is a reflection of the lack of clear policies, both in the public and private sectors.

(for overall country picture see Appendix 6, 7 & 8)

RESEARCH QUESTION 2: Are there any correlations between R&D factors and the internationalization of innovation, applicable to both regions?

The following analysis will seek to answer the second research question, utilizing correlation candidate plots and linear regressions, between World Bank economic indicators (related to innovation) as control variables and SHIA; SHAI; SHII patent indicators calculated before, as dependent variable. It covers a time period from 2010 to 2018 and 76.405 publications.

The selected World Bank indicators were as follows:

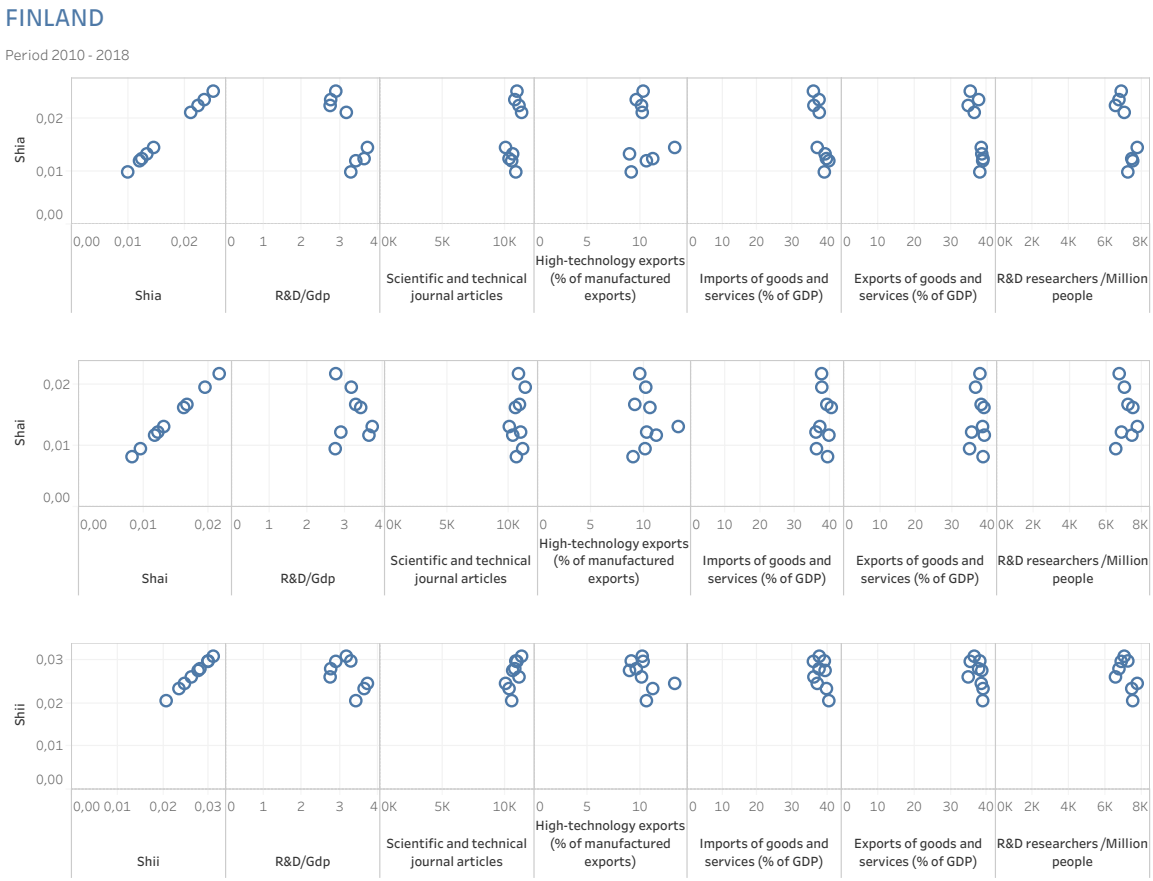
- R&D/GDP: Gross domestic expenditures on research and development (R&D), expressed as a percent of GDP. They include both capital and current expenditures in the four main sectors: Business enterprise, Government, Higher education and Private non-profit. R&D covers basic research, applied research, and experimental development.
- Scientific and technical journal articles: Scientific and technical journal articles refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.
- High-technology exports (% of manufactured exports): High-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.
- Imports of goods and services (% of GDP): Imports of goods and services represent the value of all goods and other market services received from the rest of the world.
- Exports of goods and services (% of GDP): Exports of goods and services represent the value of all goods and other market services provided to the rest of the world.
- R&D researchers / Million people: The number of researchers engaged in Research &Development (R&D), expressed as per million. Researchers are professionals who conduct research and improve or develop concepts, theories, models techniques instrumentation, software of operational methods. R&D covers basic research, applied research, and experimental development.

The following figures shows a correlation candidate plot between SHIA; SHAI; SHII and each of the economic indicators listed before. The idea, behind the elaboration of this plot, is to identify possible correlation candidates, among the factors. Afterward, the correlation of these candidate factors will be analyzed utilizing the linear regression methodology. This exercise will be repeated for each of the countries.

As a reminder, in linear regressions two coefficients are necessary to determinate the existence of correlation between paired sets of data, which are *p*-values and R-squared:

- *p*-values: A low p-value is taken as evidence that the null hypothesis can be rejected. If the data from the study results in a *p*-value of less than that specified in advance, it can be claimed that the study is significant and it enables the rejection of the null hypothesis and conclude that a relationship really exists. For this study a value of 0,05 will be taken as highly significant, which means any value above that threshold will be rejected. A *p*-value of 0,05 can be understood as that there is a 5% chance that these observations could have seen if the variables were unrelated (Fenton & Neil, 2012).
- R-squared: Measures the average of the squares of the errors for each point and the line model. Then the average from all the values is represented in the coefficient. R-squared is always between 0 and 100% and can be seen as a percentage of how many points from the sample can be predicted by the line model (0% indicates that the model explains none of the variability and 100% indicates that the model explains all the variability) (Fenton & Neil, 2012).

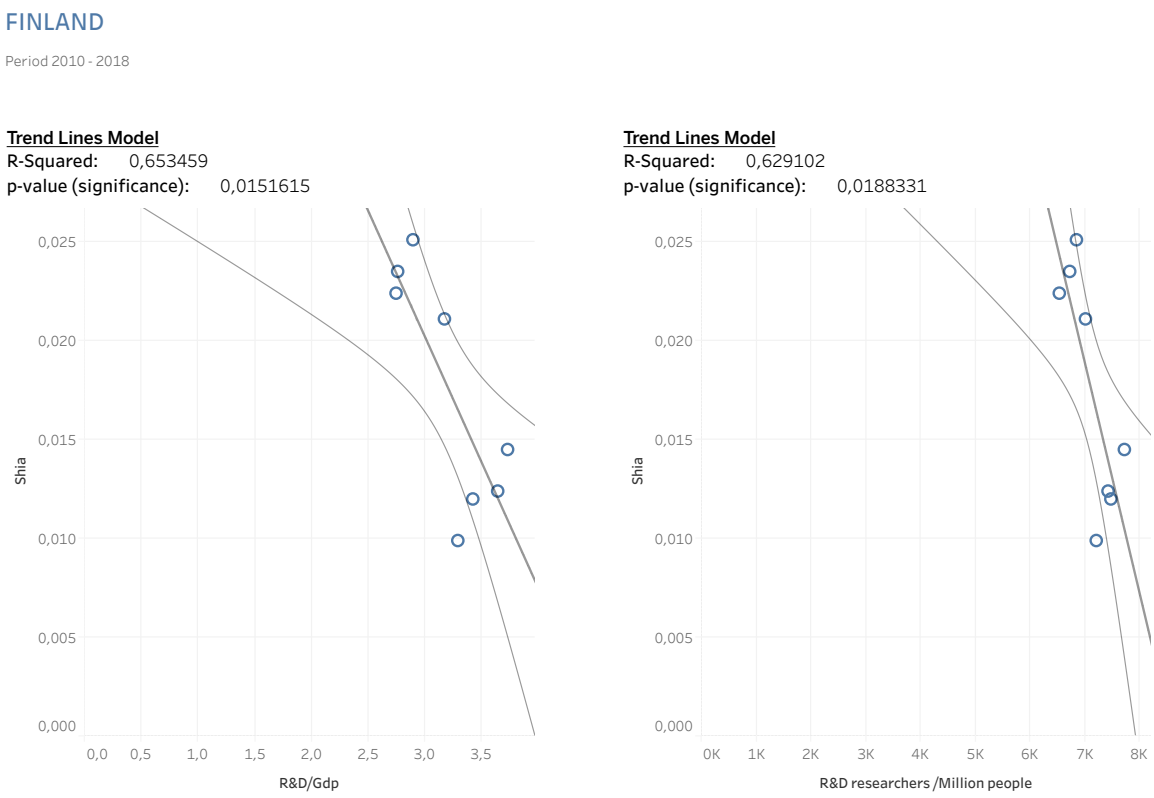
Graphic 12: Finland Correlation Candidate Plot



Own creation, Source: EPO Espacenet

In the case of Finland, the plot from SHIA exhibits the factors "R&D/GDP" and "R&D researchers / Million people" as possible correlation candidates. Next, the linear regression between them and SHIA will be analyzed.

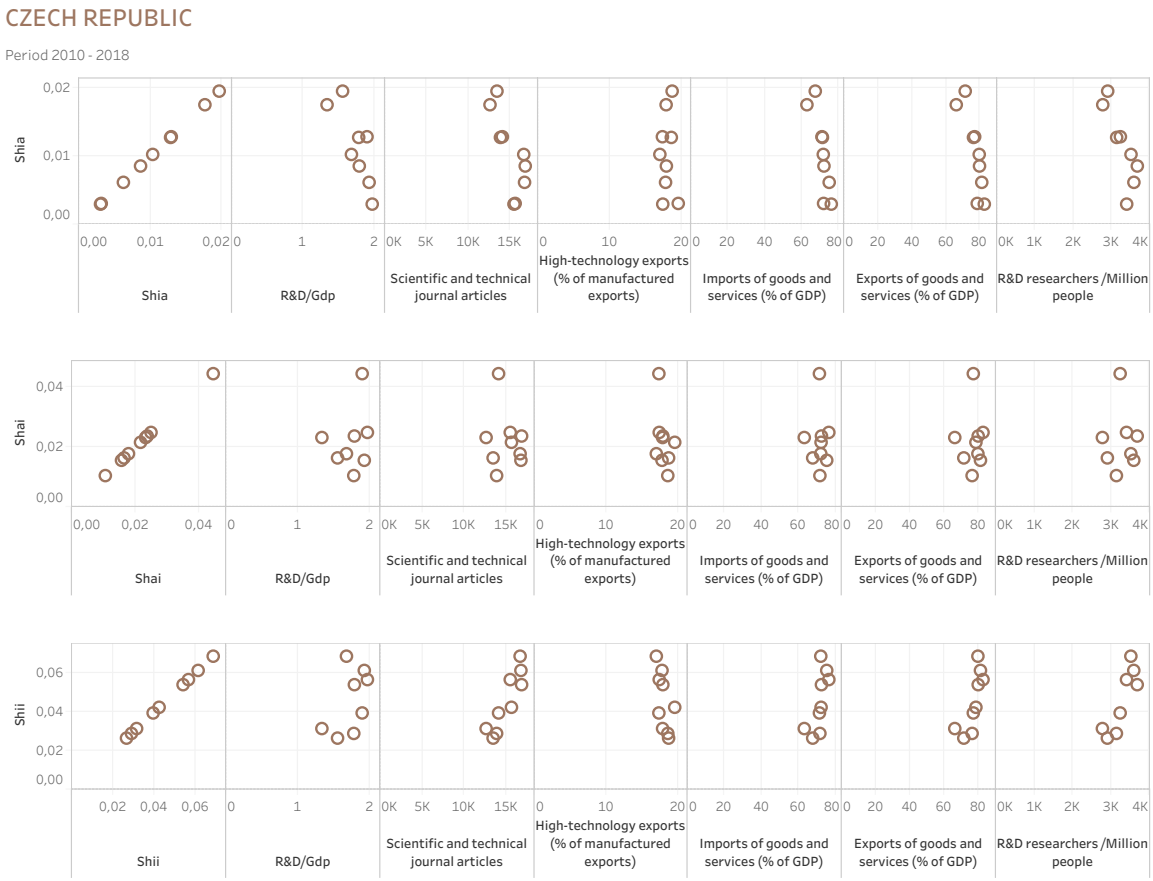
Graphic N°13: Finland Lineal Model



Own creation, Source: EPO Espacenet

As shown in the figure above, both factors present *p*-values well below the 0,05 threshold. Additionally, the line model can predict 65% of the values for "R&D/GDP" and 62% of the values for "R&D researchers / Million people". From this analysis it can be affirmed the existence of a correlation between the factors, which means the more R&D/GDP expense the less international firms own the national inventions (and same case for researchers /Million people). These results are aligned with the behavior seen previously, where Finland has more control over their own domestic inventions, than the other countries.

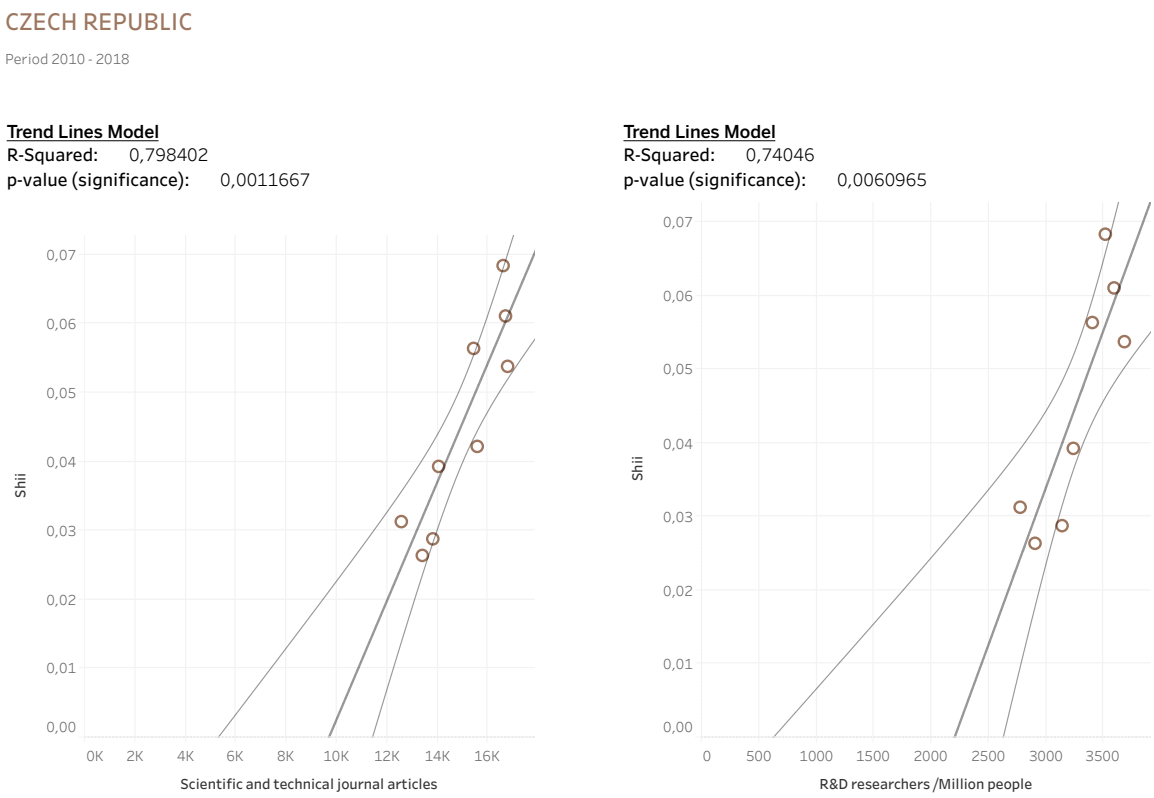
Graphic N°14: Czech Republic Correlation Plot



Own creation, Source: EPO Espacenet

In the case of Czech Republic, the plot from SHII exhibits the factors "Scientific and technical journal articles" and "R&D researchers / Million people" as possible correlation candidates. Next, the linear regression between them and SHII will be analyzed.

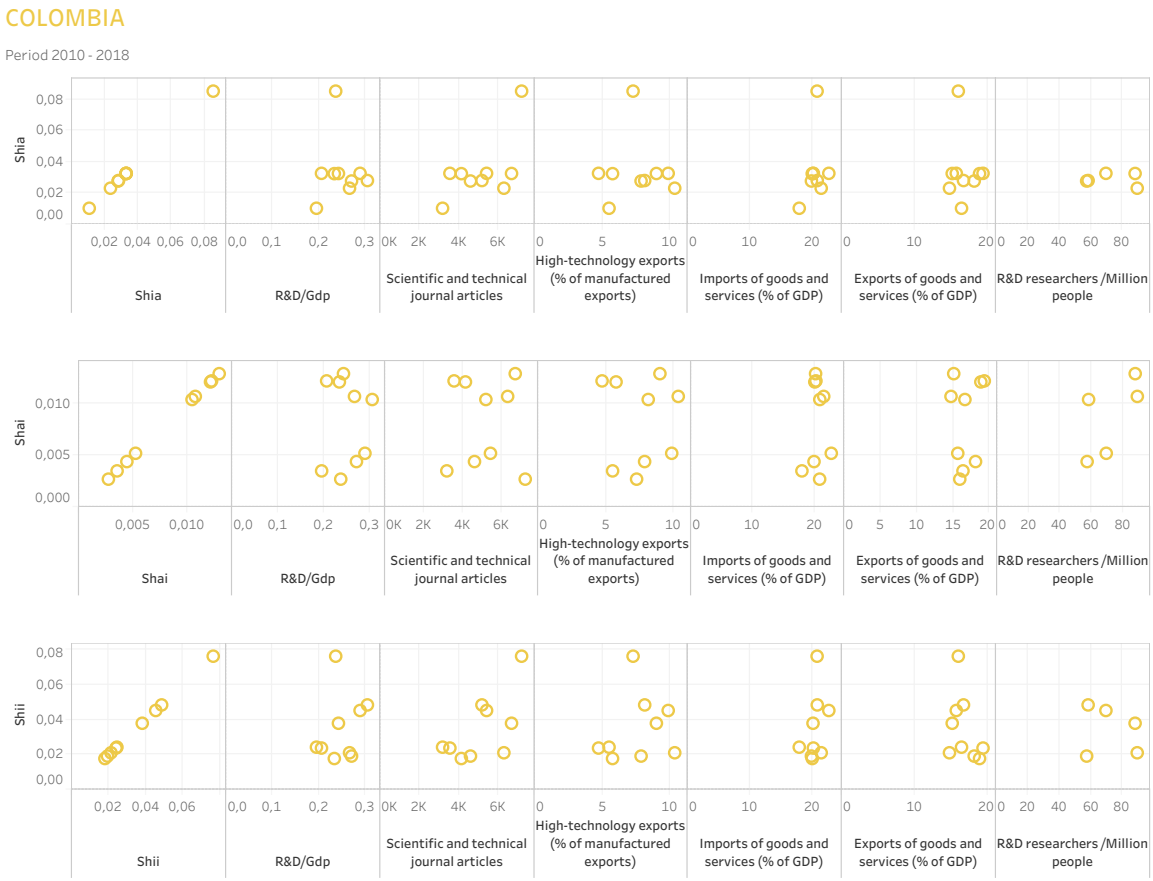
Graphic N°15: Czech Republic Lineal Model



Own creation, Source: EPO Espacenet

As shown in the figure above, both factors present p-values well below the 0,05 threshold. Additionally, the line model can predict 79% of the values for "Scientific and technical journal articles" and 74% of the values for "R&D researchers / Million people". From this analysis it can be affirmed the existence of a correlation between the factors, which means the more R&D researchers per Million people, the more collaboration between national and international researchers will happen (and same case for scientific and technical journal articles published). These results are a reflection of how the researchers from Czech Republic have a natural tendency to cooperate with international peers.

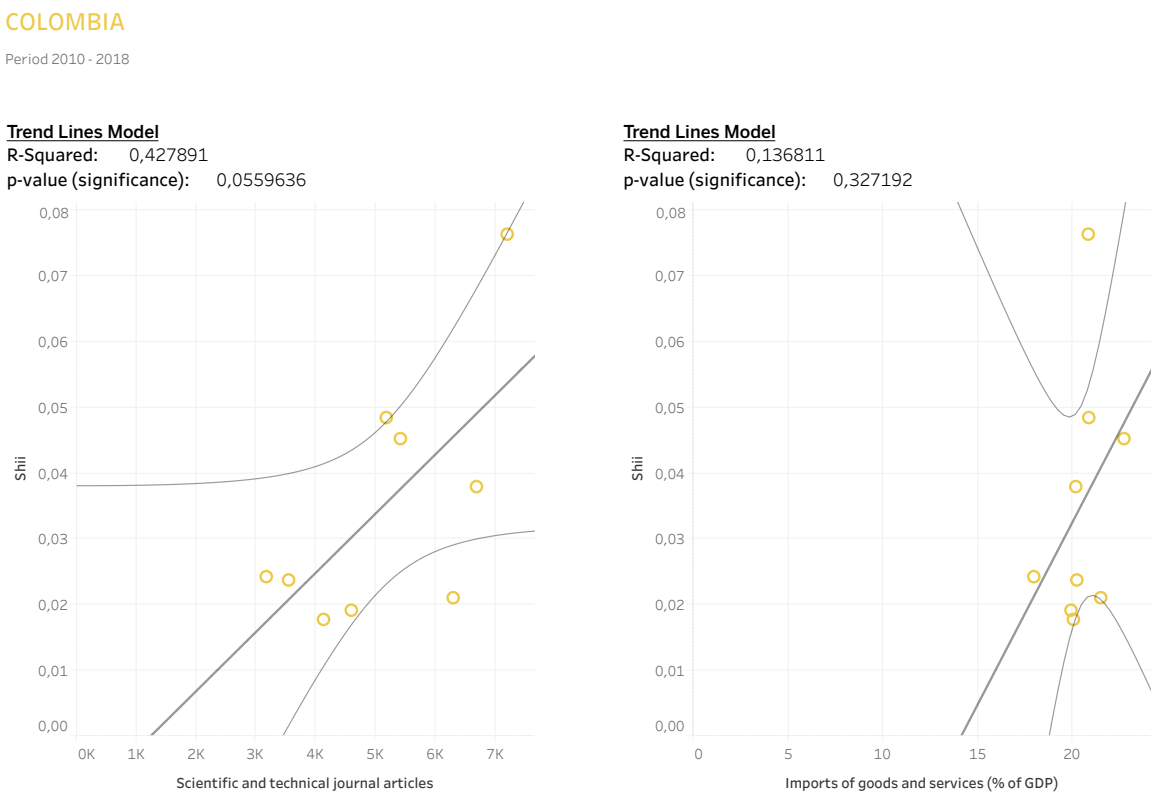
Graphic N°16: Colombia Correlation Candidate Plot



Own creation, Source: Colombia National patent database

In the case of Colombia, the plot doesn't show any evident candidates. Anyway, as a demonstration, the two most interesting plots in the SHII indicator will be analyzed with the linear regression methodology.

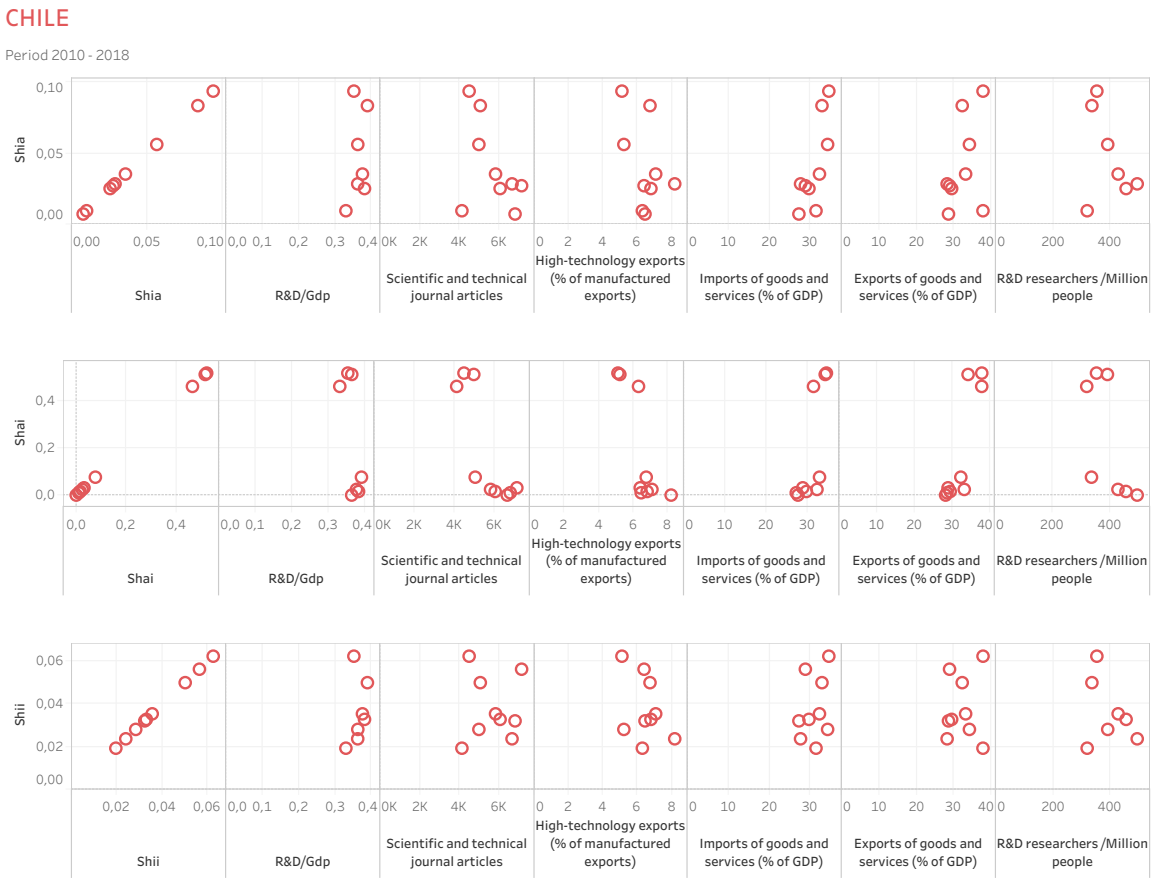
Graphic N°17: Colombia Lineal Model



Own creation, Source: Colombia National patent database

As shown in the figure above, the first factor presents a *p*-value very close to the 0,05 threshold, but still above it, the second factor is way off the threshold. Additionally, the line model can predict only the 42% of the values for "Scientific and technical journal articles" and only 13% of the values for "Imports of goods and services (% of GDP)". From this analysis it can be affirmed the non-existence of an unquestionable correlation between the factors.

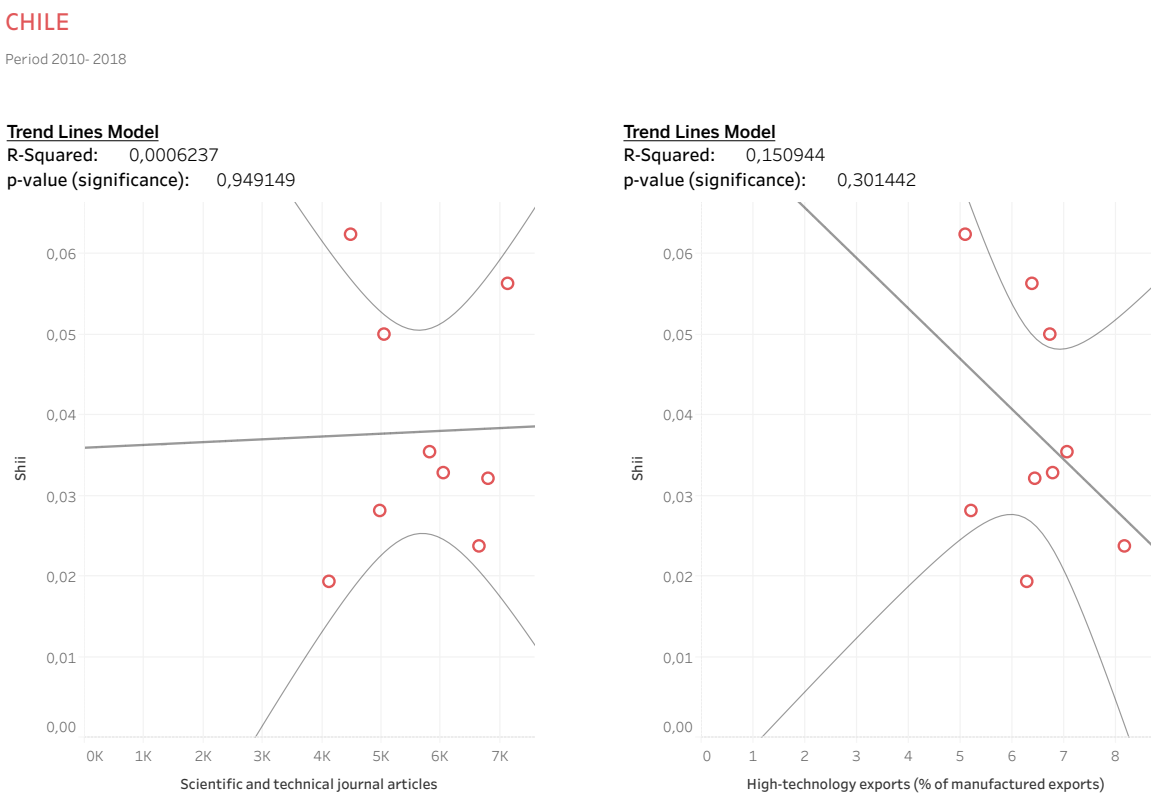
Graphic N°18: Chile Correlation Candidate Plot



Own creation, Source: Chile National patent database

In the case of Chile, again, the plot doesn't show any evident candidates. Anyway, as a demonstration, the two most interesting plots in the SHII indicator will be analyzed with the linear regression methodology.

Graphic N°19: Chile Lineal Model



Own creation, Source: Chile National patent database

As shown in the figure above, both factors present *p*-values way off the 0,05 threshold. Additionally, the line model can predict close to zero of the values for "Scientific and technical journal articles" and only 15% of the values for "High-technology exports (%of manufactured exports)". From this analysis it can be affirmed the non-existence of an unquestionable correlation between the factors.

Graphic N°20: Finland and Czech Republic Correlation Candidate Plot

Own creation, Source: EPO Espacenet

Now, by carrying out the analysis combining the two countries of both regions, it becomes evident how in the case of Europe, with Finland and the Czech Republic, it is possible to identify in the plots behaviors of the factors that show degrees of correlation. For instance, SHII and "Scientific and technical journal articles" stands out.

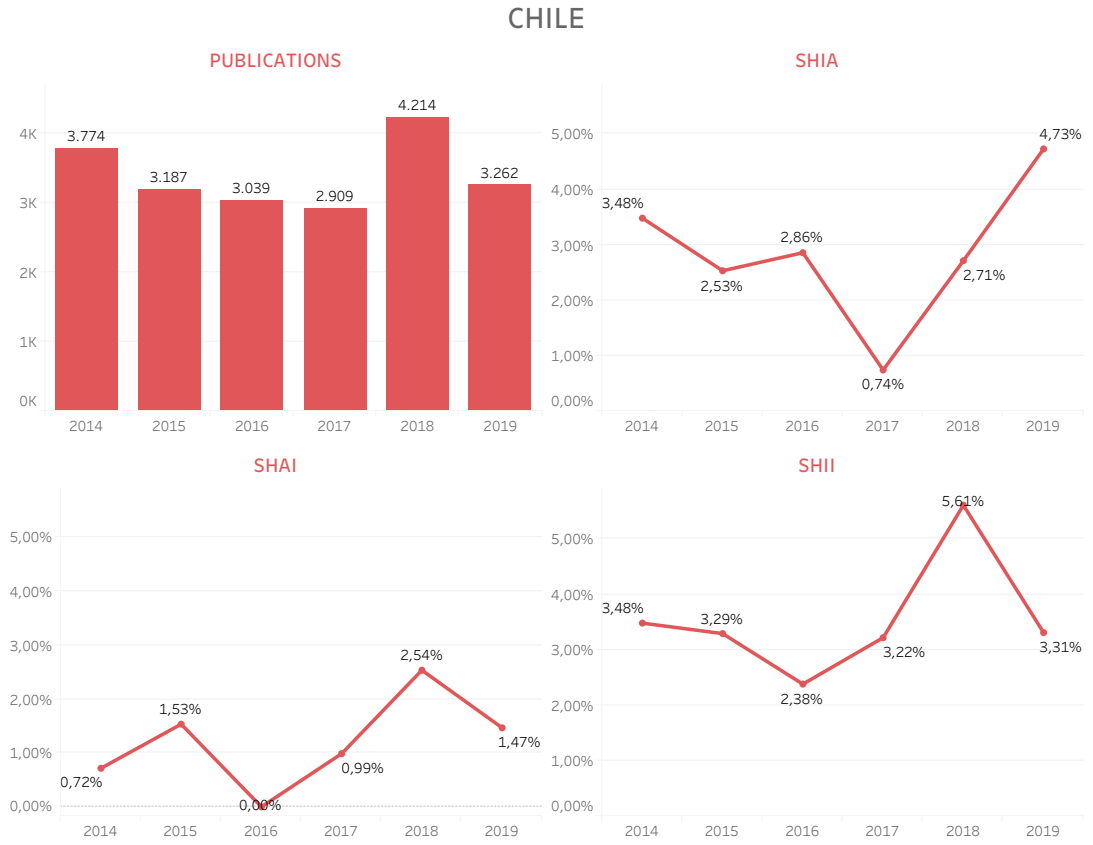
Graphic N°21: Colombia and Chile Correlation Candidate Plot

Own creation, Source: Colombia & Chile National patent database

But in the case of Colombia and Chile combined, again, the plot doesn't show any evident candidates, where the points are well scattered throughout the plane, evidencing a lack of correlations.

F. DISCUSSION OF RESULTS

Graphic N°22: Position of Chile Regarding Internationalization of Innovation



Own creation, Source: Chile National patent database

After carrying out the study, it is possible to affirm that Chile is in a better position with respect to the other representative country of South America (Colombia) in terms of investment in R&D over GDP, but both countries are in an inferior overall position in terms of the internationalization of innovation, due to the great variability of these indicators. In opposition, when comparing Chile with Europe (Finland and the Czech Republic), the country presents both; a huge disadvantage in R&D over GDP and presents a negative position regarding the internationalization of innovation.

Second, it was not possible to identify factors that promote internationalization that are applicable to both regions. In the case of Europe, it was possible to find correlations between the factors and the internationalization of innovation for Finland and Czech Republic. On the contrary, in South America, no correlations were detected.

All things considered leads to the conclusion that in South America, and specifically in Chile, the low amounts of investment in R&D, the high variability of indicators and the absence of

correlations are a reflection of a lack of a country long-term vision about the importance of innovation for the development of the countries and the region. Where the variability of cooperation indicators can be also explained due to reasons of historical rivalries and cultural conflicts not yet resolved that hinder cooperation between peers in the region.

As samples of this low cooperative development, the lack of fiber optic interconnectivity among the countries of the continent can be mentioned. In the case of Chile connected directly to California through an undersea fiber optic cable[5], but not directly connected to its neighboring country Argentina, implying that all traffic between these two countries must leave the region and then return, generating all the respective inefficiencies, that directly impact cooperative research between those two countries. In the case of Europe, it is easy to find examples of cooperation between researchers of the continent, just to mention one case, Airbus stands out, which involves a variety of European countries in the development of the activity. Something impossible to observe in this magnitude in the South American region.

The reasons for this lack of cooperation cannot be explained exclusively due to economic factors but also for social and cultural reasons that this study cannot cover. Therefore, future investigation, with researchers from other disciplines, may cover the social and cultural motives involved.

As a suggestion, to improve the scenario that Chile is currently in, the following may be advised:

1) Economic: Increase the R&D expenses over GDP (from public and private sectors) to similar rates of nations members of the OECD, since the country has an economy mainly focused on the extraction and exportation of natural resources. As a consequence, the increase in spending will make the country more competitive and not so dependent on fluctuations in the international prices of these commodities, because successful innovation provides a continuing source of competitive advantage[6].

To bear this point, it must be remembered the study of Miguel Benavente (2004), considering the level of economic development of Chile, there are serious deficiencies in the National System of Innovation. The country has very low resources designated to R&D as a proportion of GDP, very few scientific workforce and professionals dedicated to research activities, as well as a scare participation (involvement) of the private sector in financing these activities. Expenditure on R&D is low as a share of GDP, especially in the business sector. ("OECD Economic Surveys: Chile," 2018).

More in depth, one of the weakness indicators in the capacity of private firms to innovate and commercialize research is given by the discrepancy between R&D expenditures in the private and public sectors. Comparing with OECD countries, it is possible to observe in the OECD, private firms finance two-thirds of the R&D expenses while in Chile the private sector finances

[5] The submarine cable system, dubbed the "Curie" and completed by Alphabet Inc's Google in 2019, is a four-fibre-pair and 10,500km cable connecting Los Angeles, California, and Valparaiso, Chile.

[6] The bases of competitive advantage are superior resources and organizational capabilities from the value chain. In order to keep a sustained competitive advantage, the resource or capability must be Valuable, Rare, Inimitable and Organized.

only one-third of the R&D expenses. Also, for example, European governments use different mixes of innovation policy instruments. These instruments are implemented to foster public R&D and to stimulate private business R&D expenditures. These are possibly subject to market failures which lead to an underinvestment in R&D from a social point of view. Externalities and information asymmetries are commonly recognized as the most important market failures hampering R&D investment. Due to these market failures, and for reasons of competitiveness, governments employ policy tools like patent laws, R&D grants, low interest loans or tax incentives to strengthen national R&D activities (Czarnitzki et al., 2007).

An illustration that reflects the relationship between increased R&D spending and tremendous changes in economic growth is Korea. In the early 1960s, Korea had R&D spending on GDP of 0.35% (similar to the current situation in Chile). This figure has increased steadily for more than 6 decades, reaching an expense above 4% in recent years. This large increase in R&D spending has been credited as one of the main factors of the enormous economic growth that this country has experienced, positioning it today as one of the largest and most technologically innovative economies in the world, raising the quality of life of its inhabitants to the highest standards (Alvarez et al., 2010). (see Appendix 2 to observe Korea R&D/GDP evolution between 1970 and recent years).

On the other hand, as an idea to help keep the cooperation indicators more constant over time, considering the important role of this cooperation as a booster of innovation, the example of "Team Finland" can be explored, which was created to coordinate the activities of several institutions, with a focus on internationalization. This brings together a range of government-funded organizations to support cooperation between higher education institutions and businesses (Prime Minister's Office, 2015) ("OECD Economic Surveys: Finland," 2016). This could be an indication to replicate in the country and the region, as to impulse the development of cooperation and therefore, impulse the economic growth.

2) Cultural: Promote cooperation in all type of areas among the countries of the region, leaving in the past the various senseless rivalries between nations. This change will result, as a consequence, in a better cooperation in innovation in the future. It must be understood that the growth and development of the region as a whole will lead each country to a state of greater well-being. However, it is necessary to bear in mind the difficulties that arise in South America for greater integration and cooperation. These include the historical inclination to look at the United States and Europe instead of neighboring countries, the different development strategies, constant political instability in at least one of its countries, and the reluctance to cede sovereignty to supranational entities. All this has hampered progress in integration and cooperation. It is kept in mind though that these topics are beyond the scope of this thesis and could be better explored in depth by future studies.

Management Recommendations

Nowadays is more difficult for a firm to succeed in the market by doing everything by themselves. R&D collaboration (locally and internationally) has become essential to develop new technologies and therefore to be more competitive, as not all ideas come from the internal side of the company, bust mostly from the outside of a firm's boundaries. Product life cycles are becoming every day shorter and cost and time to develop new projects are getting very costly. Resources from external parties are key to survive in this globalized world, and therefore, to develop a country economically. As it was mentioned previously in the study, economic growth relies on knowledge, innovation and R&D activities, been these the engines to move development forward and to create more competitiveness. The indicators analyzed can explain some of the reasons why then Chile (and South American countries in general) is still way below OECD standards in terms of economic development.

So, as recommendations for firms inside Chile, would be to open up their businesses, invest more in R&D, associate with partners (start-ups, research institutes, universities, among others) locally and internationally. In the case of multinationals, promote cooperation between different branches, encourage research and development within the region, support the movement of employees between countries. Additionally, to promote through partnerships the creation of a node of sensing networks (global networks of innovation) in the region. Currently these innovation hotspots are found mostly in California, the east coast of the USA, Europe and China, but since South America has enough highly skilled human capital, multinational companies could start looking this region and try to gradually position this part of the world in that direction. In a nutshell, go towards a vision of regional development, which in the long run will be more beneficial for all South American countries. It is no possible yet to compare Chile to highly developed economies members of the OECD, but the country must take into account their examples in order to reach a sustainable economic growth, and so be able to reduce poverty and inequalities.

G. CONCLUSION

After the analysis and answering the initial question, it can be affirmed that Chile and Colombia both have a disadvantage with respect to internationalization of innovation due to the great variability of the SHIA, SHAI, SHII indicators across time.

Firstly, Chile allocates more resources of their GDP for R&D activities than Colombia, and this point is absolutely important for answering the question, because in order to have a significant internationalization of innovation is essential to have a minimum floor of it. Unfortunately, due to little spending efforts involved in the region, the advantage in the gap between the two countries is trivial. Secondly, and going straight to the indicators of internationalization, Chile presents in some cases a better overall SHIA; SHAI; SHII indicators than Colombia. But as mentioned before, the values of the indicators showed little consistency, and much variability between years, making the predictability of these values unquestionable challenging for the future, and making the measure of the internationalization undoubtedly problematic as well.

Regarding the comparison with Europe, Chile is tremendously below in terms of the percentages of GDP resources allocated for R&D. Additionally, Europe presented a greater coherence of the indicators throughout the years of this study. It will be a challenge for Chile, in the future, to reduce this variability in order to become more like leading innovation economies.

It can be concluded that the fluctuating position of Chile, regarding the internationalization of innovation, is not that relevant due to the low amount of research in the region and due to the excessive variability. On the other hand, the analysis reveals the country's need to increase its budget commitments through research and development in order to aspire to be in a position within the magnitudes of the European region. Likewise, it is important to establish a clear direction and objectives for the future in terms of cooperation in research, in order to reduce the peaks in the indicators, since these excellent years followed by really poor ones or vice versa, reflect low consistency in the course and reflect the non-existence of a long-term vision.

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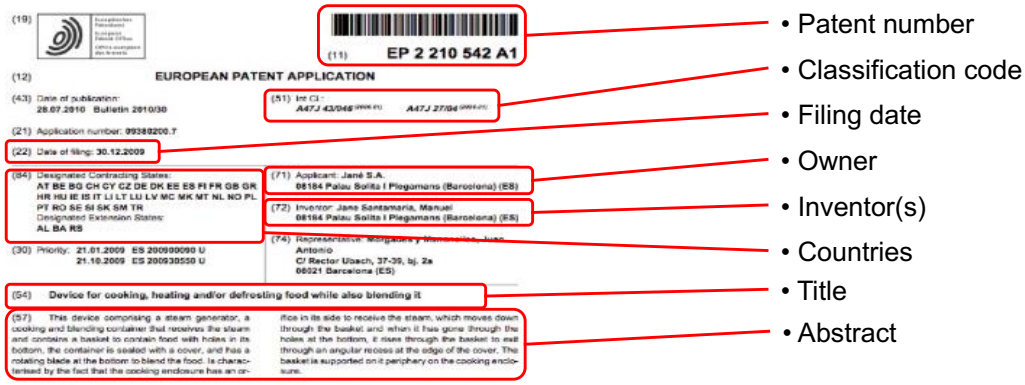
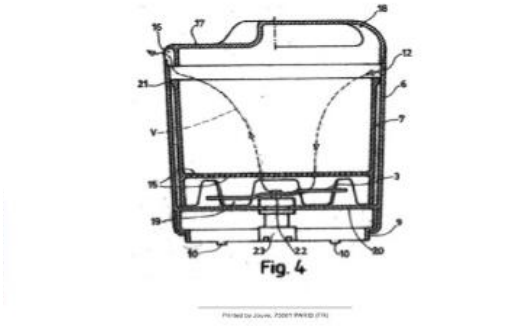
APPENDICES

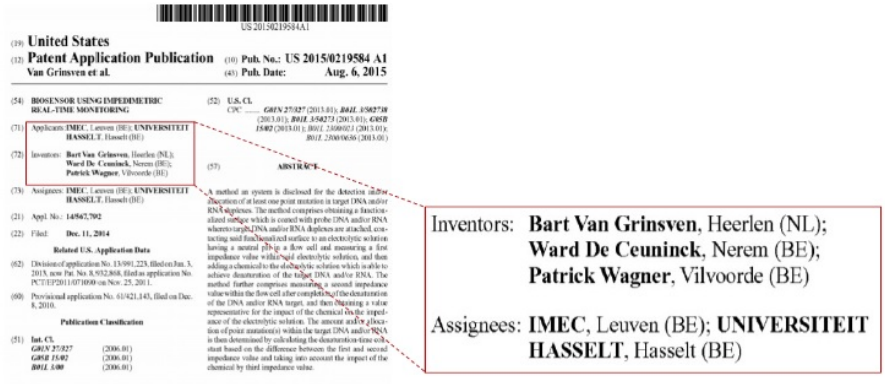
1. PATENTS

a) Patent structure

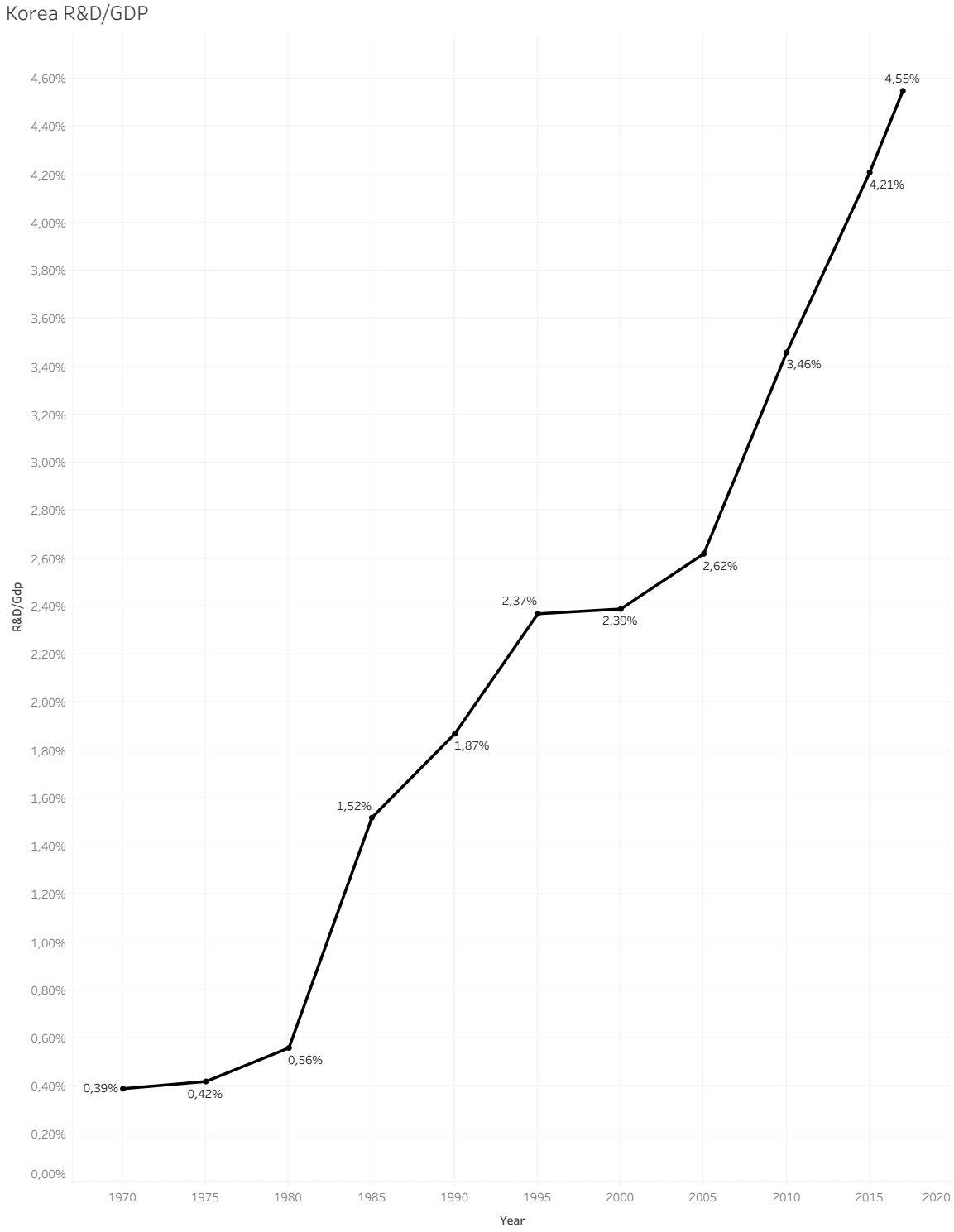




b) Patent collaboration example (UHasselt)

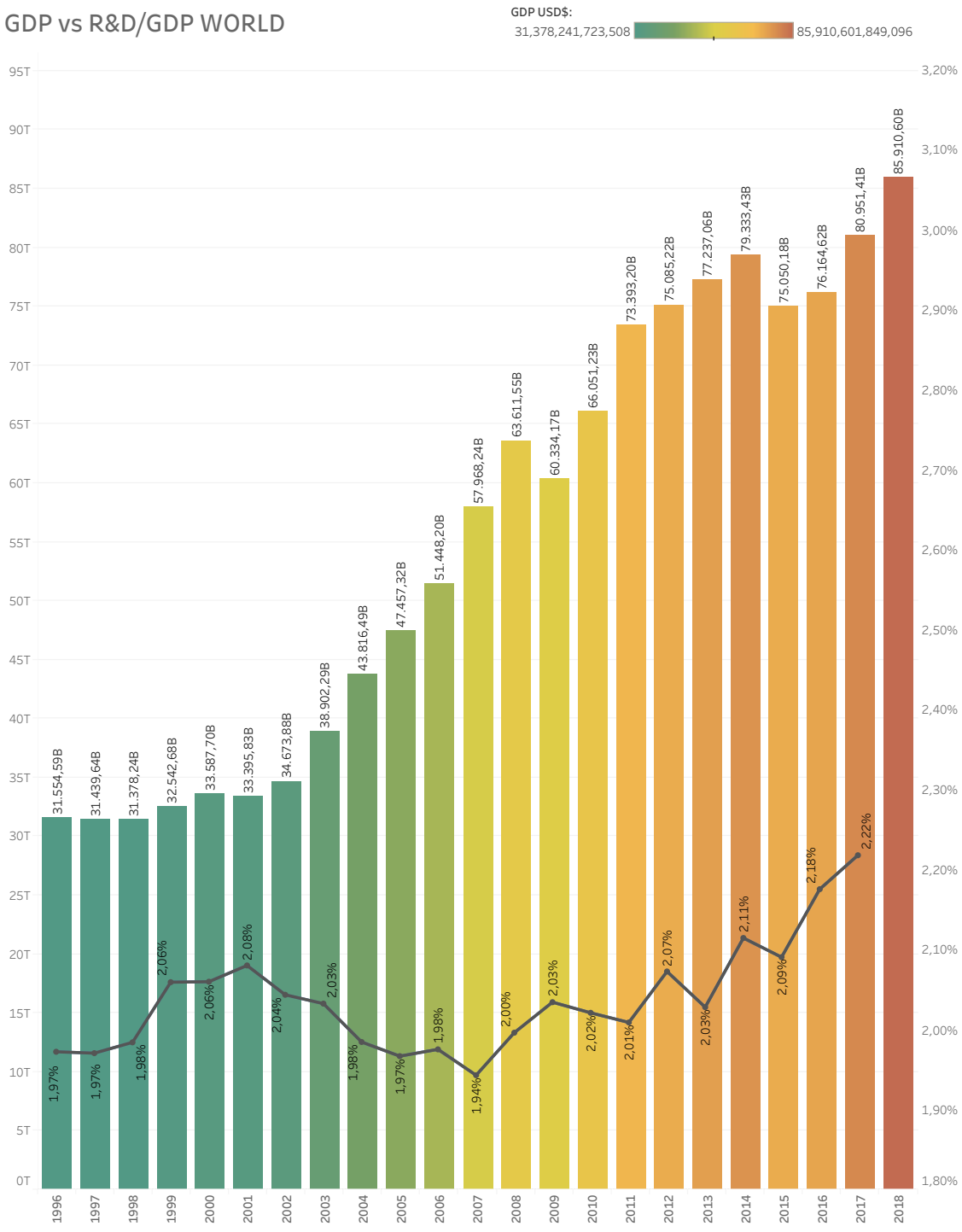


2. Korea R&D/GDP

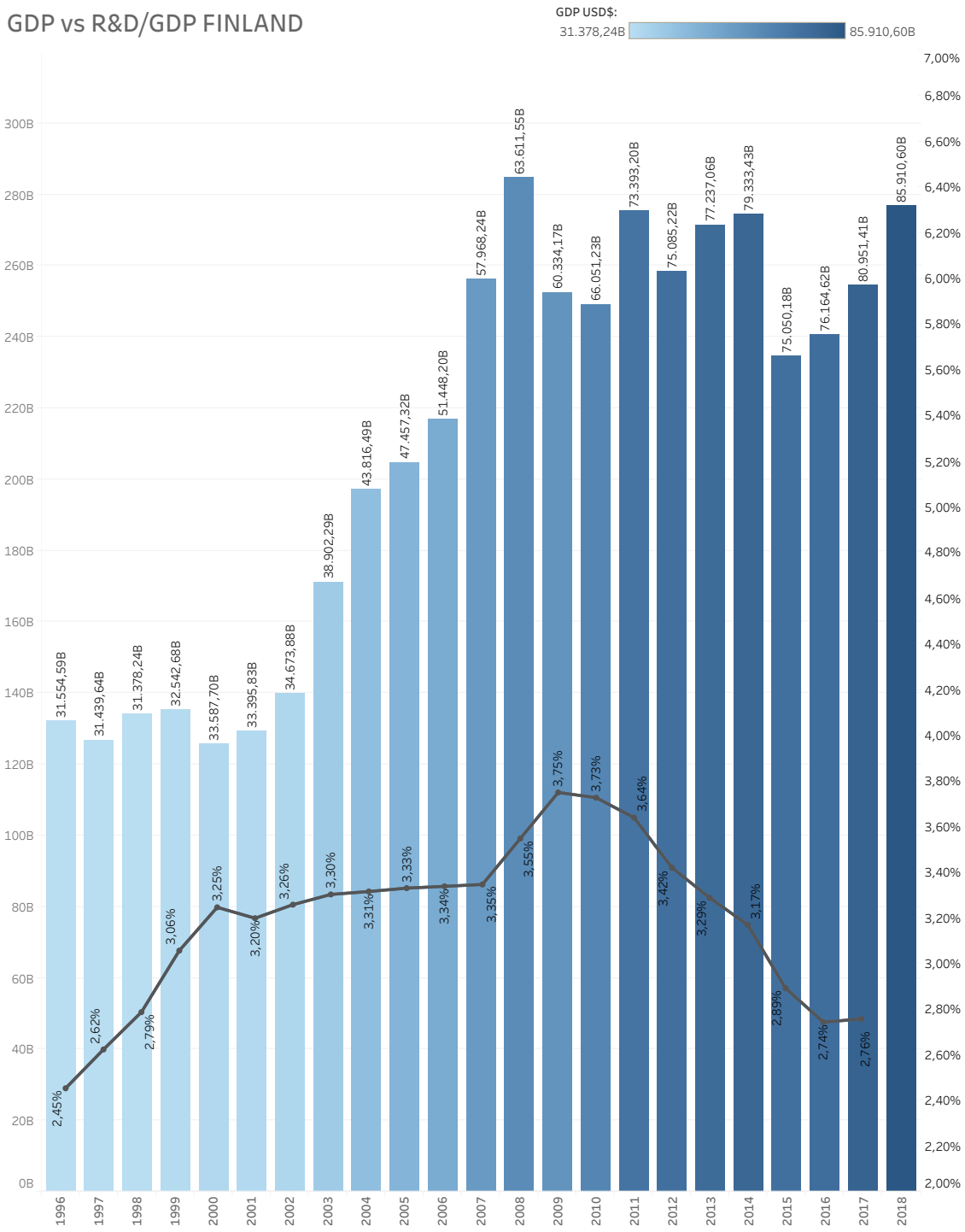


Own creation, Source: The World Bank & Korea Institute of Science and Technology Evaluation and Planning

3. GDP vs R&D/GDP



Own creation, Source: The World Bank



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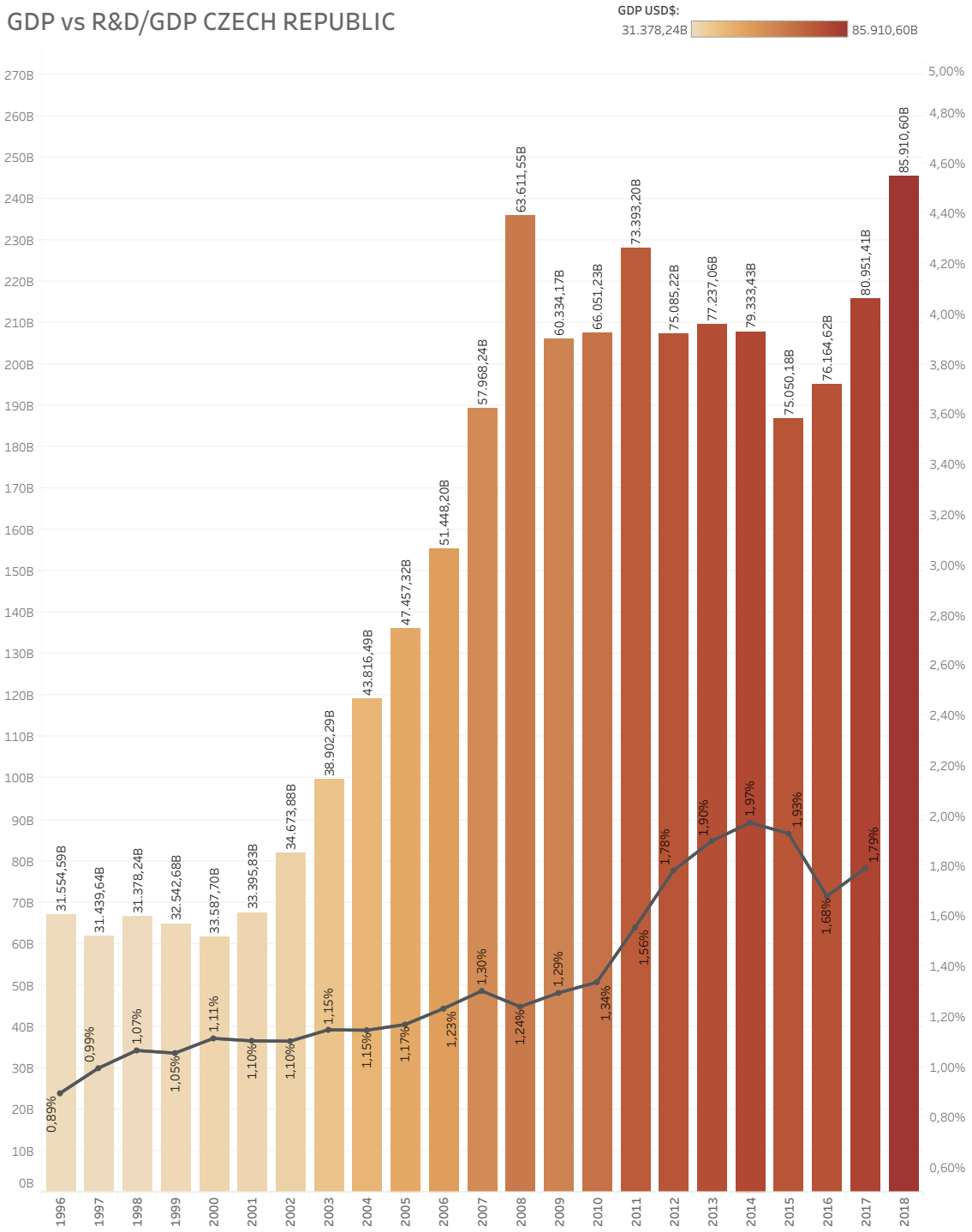

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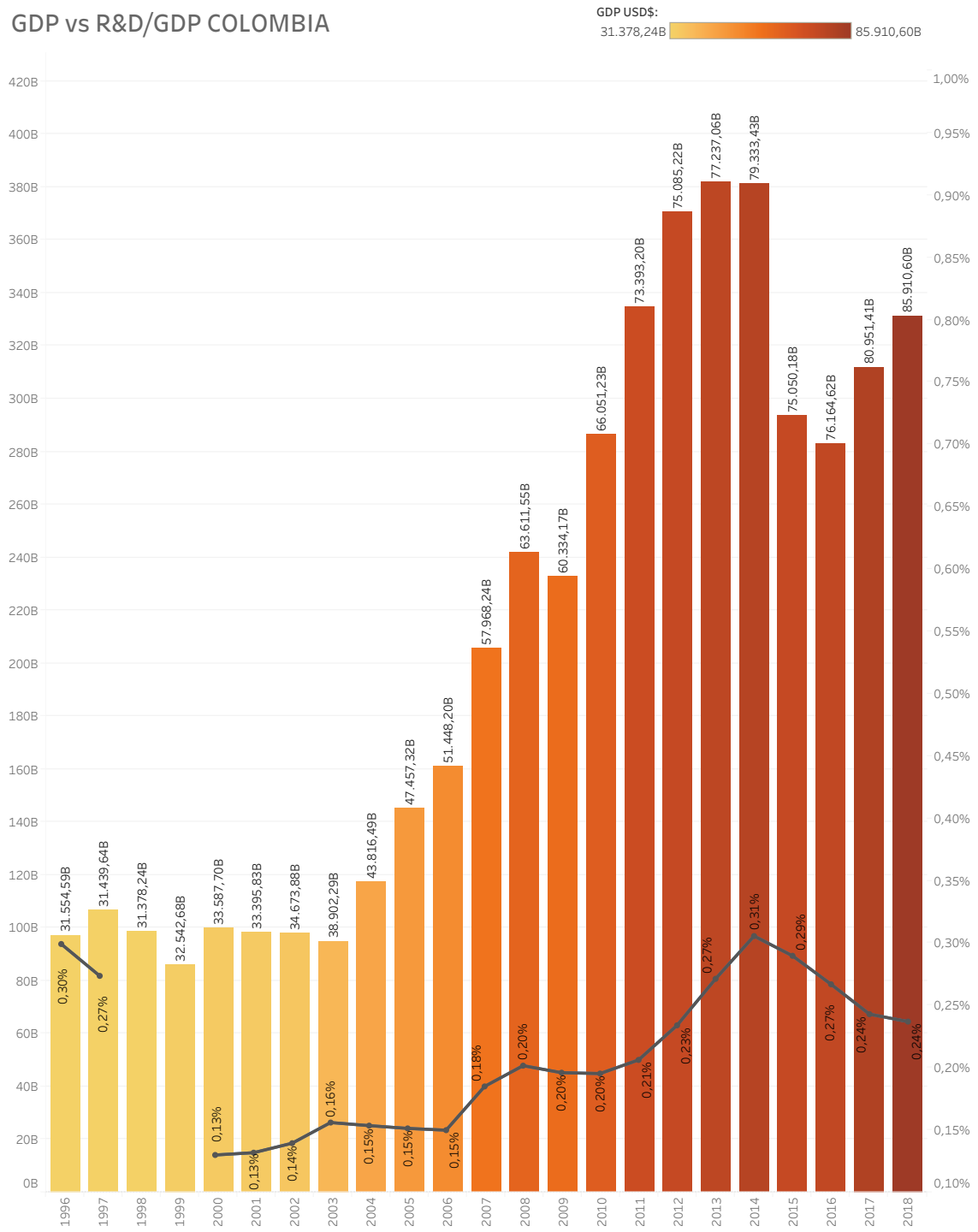

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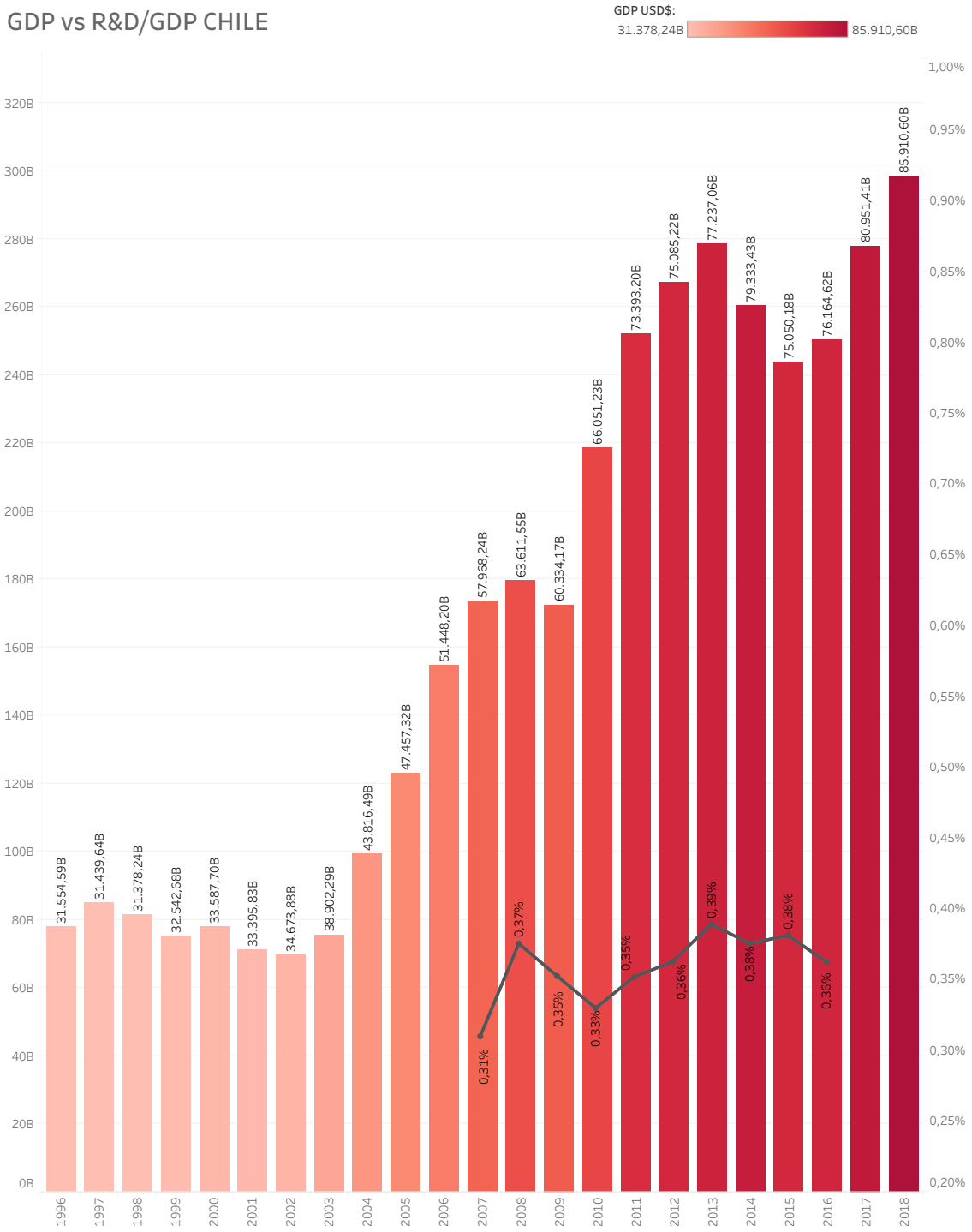


Own creation, Source: The World Bank

4. R&D/GDP AVG (1996-2017)

Own creation, Source: The World Bank

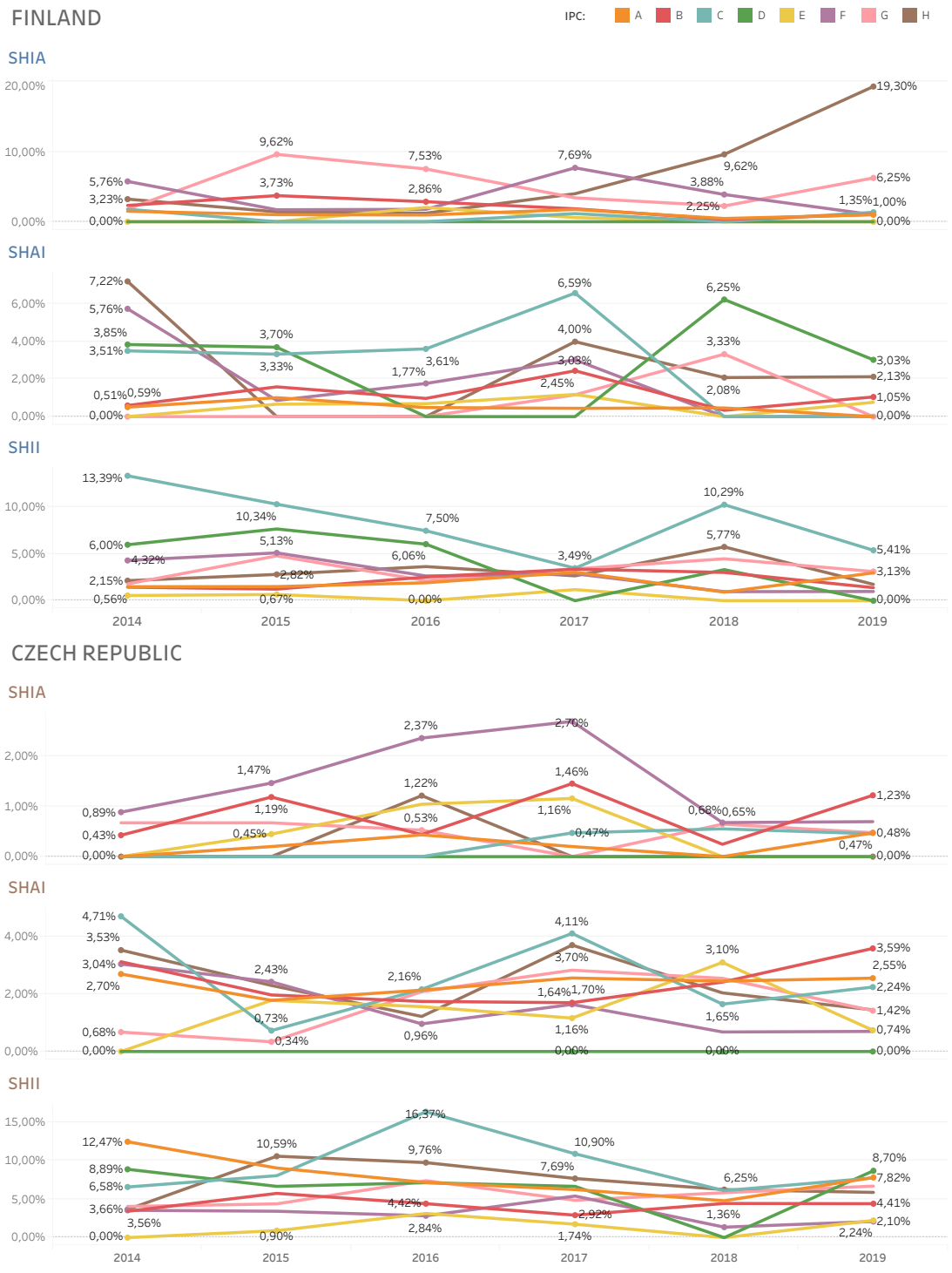
COUNTRY NAME	R&D/GDP
ISRAEL	3,92%
SWEDEN	3,37%
FINLAND	3,19%
JAPAN	3,11%
KOREA, REP.	3,09%
SWITZERLAND	2,79%
UNITED STATES	2,64%
DENMARK	2,60%
NORTH AMERICA	2,57%
GERMANY	2,57%
AUSTRIA	2,41%
ICELAND	2,36%
FRANCE	2,15%
BELGIUM	2,04%
SINGAPORE	2,01%
AUSTRALIA	1,97%
NETHERLANDS	1,82%
CANADA	1,82%
SLOVENIA	1,72%
NORWAY	1,67%
UNITED KINGDOM	1,62%
LUXEMBOURG	1,47%
CHINA	1,40%
CZECH REPUBLIC	1,35%
IRELAND	1,28%
ESTONIA	1,19%
ITALY	1,15%
NEW ZEALAND	1,14%
BRAZIL	1,12%
SPAIN	1,10%
RUSSIAN FEDERATION	1,09%
PORTUGAL	1,03%
HUNGARY	1,02%
UKRAINE	0,87%
CROATIA	0,86%
MALAYSIA	0,85%
SOUTH AFRICA	0,78%
UNITED ARAB EMIRATES	0,76%
LITHUANIA	0,76%
INDIA	0,76%
POLAND	0,71%
SLOVAK REPUBLIC	0,69%

Montenegro	0,69%
Greece	0,69%
Serbia	0,68%
Belarus	0,68%
Rwanda	0,67%
Tunisia	0,66%
Turkey	0,66%
Kenya	0,57%
Malta	0,57%
Morocco	0,56%
Greenland	0,56%
Bulgaria	0,55%
Latvia	0,51%
Qatar	0,50%
Argentina	0,49%
Jordan	0,49%
Iran, Islamic Rep.	0,48%
Cuba	0,47%
Romania	0,46%
Botswana	0,44%
Puerto Rico	0,44%
Senegal	0,43%
Moldova	0,43%
Costa Rica	0,42%
Mexico	0,41%
Tanzania	0,41%
Egypt, Arab Rep.	0,40%
Sudan	0,40%
Cyprus	0,38%
Chile	0,36%
Mozambique	0,36%
Mali	0,35%
Saudi Arabia	0,35%
Vietnam	0,34%
Thailand	0,34%
Uruguay	0,33%
Uganda	0,31%
Ghana	0,30%
Ethiopia	0,29%
Bolivia	0,28%
Pakistan	0,27%
Algeria	0,26%
Azerbaijan	0,26%
Georgia	0,25%
Burkina Faso	0,25%
Venezuela, RB	0,24%

Armenia	0,24%
Namibia	0,24%
Uzbekistan	0,23%
Mongolia	0,22%
Panama	0,22%
Ecuador	0,21%
Colombia	0,21%
Oman	0,21%
Bermuda	0,21%
Nepal	0,21%
Kazakhstan	0,20%
Congo, Dem. Rep.	0,16%
Kuwait	0,15%
Madagascar	0,14%
Sri Lanka	0,14%
Nigeria	0,13%
Indonesia	0,13%
Philippines	0,13%
Bosnia and Herzegovina	0,12%
Albania	0,12%
Peru	0,10%
Bahrain	0,10%
El Salvador	0,10%
Cote d'Ivoire	0,10%
Trinidad and Tobago	0,09%
Cambodia	0,08%
Nicaragua	0,08%
Paraguay	0,08%
Myanmar	0,07%
Jamaica	0,06%
Zambia	0,05%
Guatemala	0,04%
Iraq	0,04%
Honduras	0,04%
Angola	0,03%
Papua New Guinea	0,03%
Syrian Arab Republic	0,02%

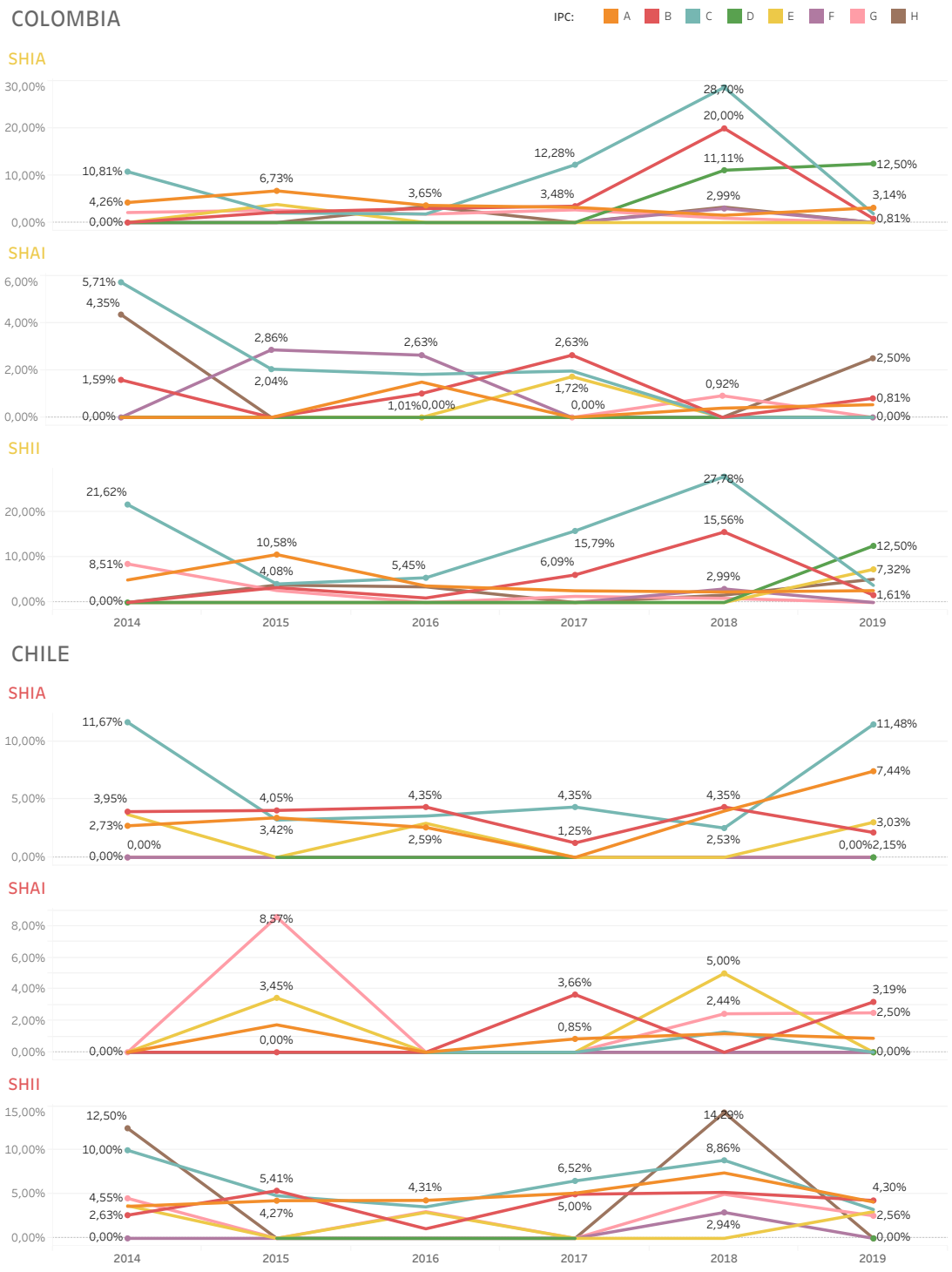
5. SHIA, SHAI, SHII / IPC

a) Europe



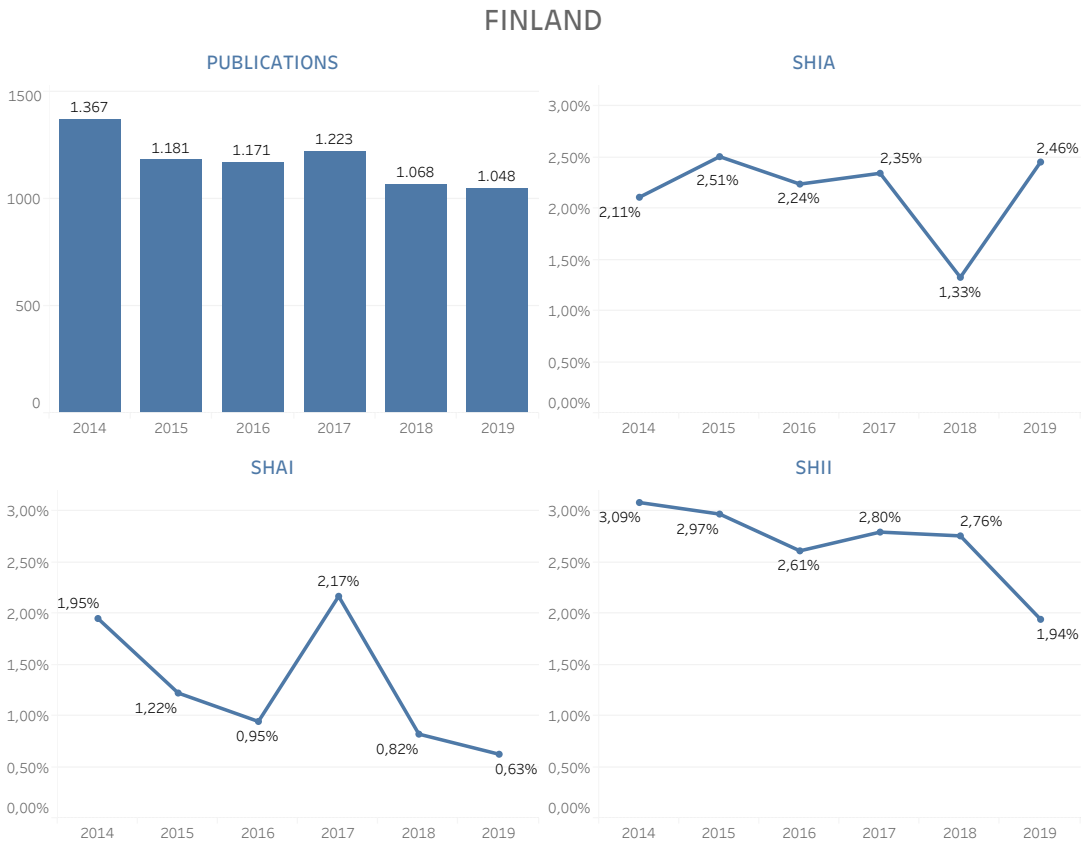
Own creation, Source: EPO Espacenet

b) South America



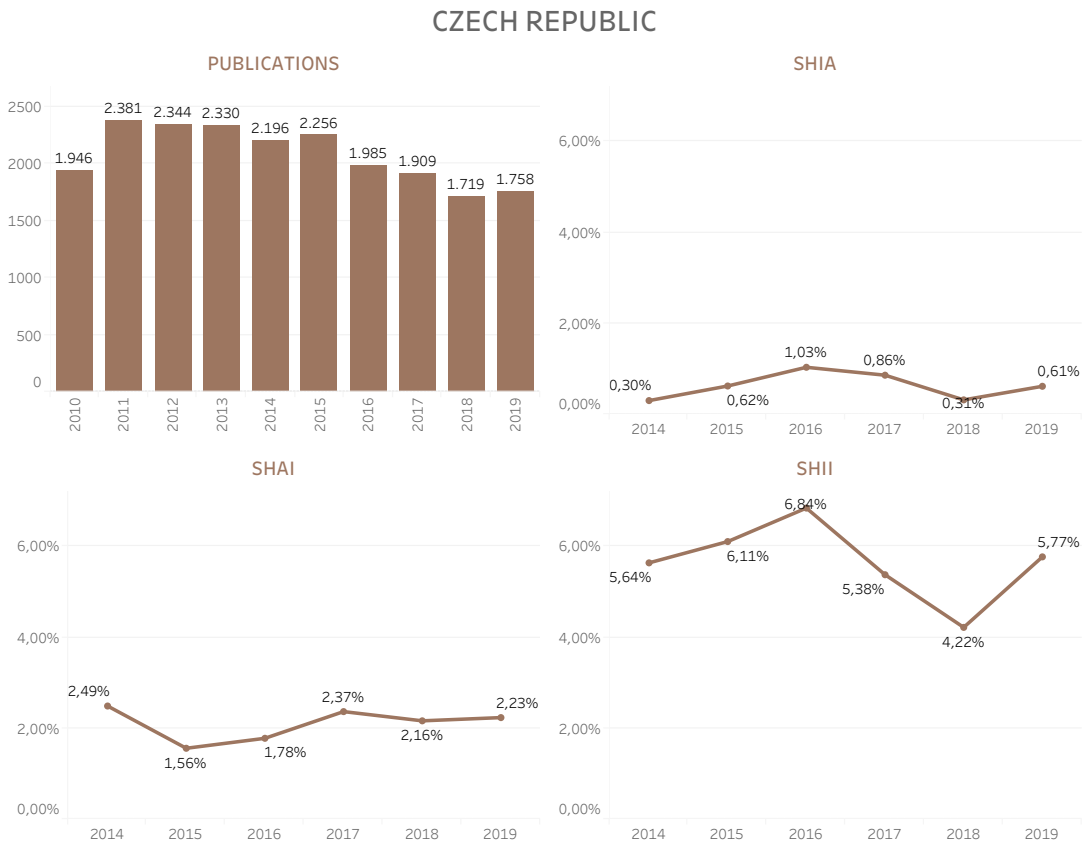
Own creation, Source: Colombia & Chile National patent database

6. FINLAND OVERALL INDICATORS



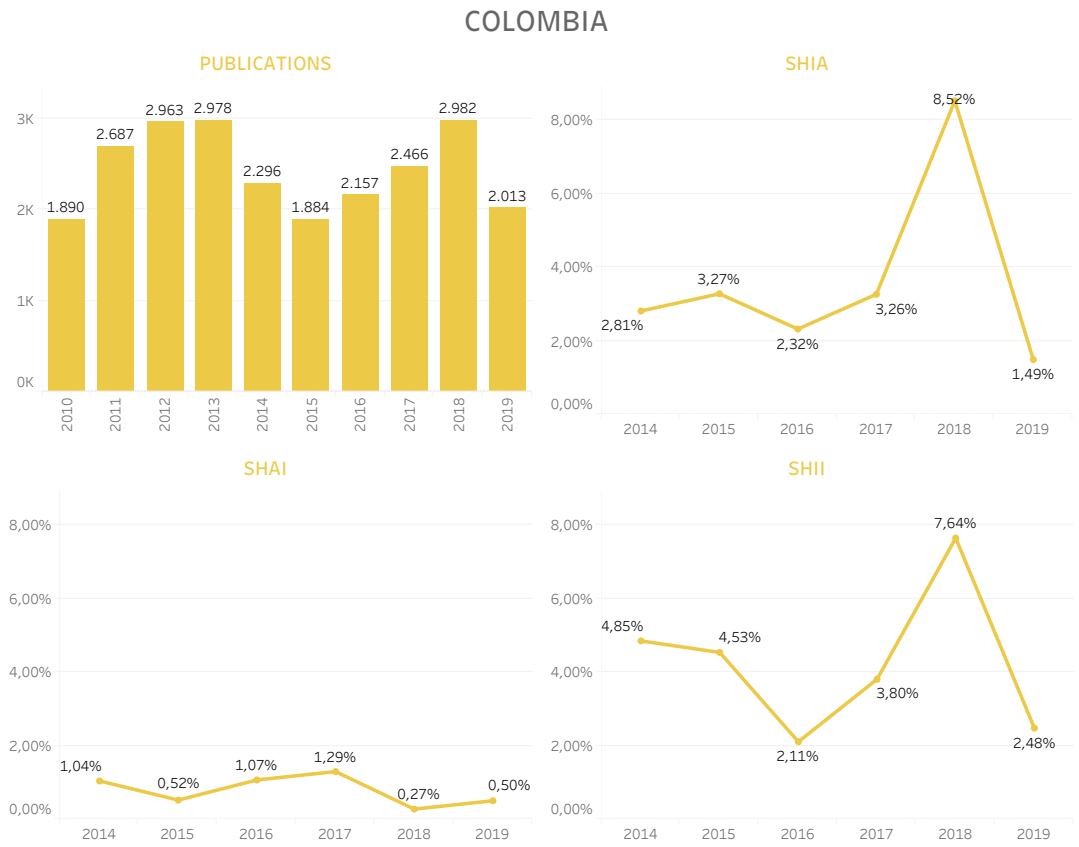
Own creation, Source: EPO Espacenet

7. CZECH REPUBLIC OVERALL INDICATORS



Own creation, Source: EPO Espacenet

8. COLOMBIA OVERALL INDICATORS



Own creation, Source: Colombia National patent database