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Navn:	Camilla Lossius Strandli og Silje Kirkebø Arntzen

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Authors: Camilla Lossius Strandli and Silje Kirkebø Arntzen

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Supervisor: Per Botolf Maurseth

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Executive Summary

This thesis explores how the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) has influenced patent application trends in developed and developing countries. It focuses on the patent system and analyzes how TRIPS implementation affects the number of applications from residents and non-residents. The patent system, as a crucial facilitator of innovation and economic development, has been a topic of ongoing debate particularly in the context of the TRIPS agreement. This treaty mandates the enforcement of specific minimum standards for intellectual property rights, including patent rights, amongst World Trade Organization (WTO) members.

Our study conducts a comprehensive examination of Intellectual Property Rights (IPR) laws across 68 countries between 1980 and 2021. It employs a Fixed Effects (FE) model using a patent protection index developed by W. Park and J. Ginarte in 1997 and subsequently extended. We refer to this index as the Park Index (PI). It serves as a crucial tool in assessing the strength and evolution of patent protection across the countries under study. This approach is supplemented by insight and experiences from an interview conducted with G. Holen, the CEO of Nordic Electorufel.

Two principal hypotheses guide our exploration. The first suggests that TRIPS implementation prompts an increase in non-resident patent applications, whereas resident applications in developing countries see no growth. The second hypothesis proposes that TRIPS implementation triggers a larger relative increase in resident patent applications in developed countries compared to non-resident applications. Our findings lend significant support to the first hypothesis, while the validation of the second hypothesis presents a more complex scenario.

The results from this investigation not only contribute to the ongoing TRIPS debate but also shed light on the intricate dynamics of the patent system. The nuanced findings underscore the distinction between resident and non-resident patent applications and the differences between developed and developing countries, thus offering a valuable foundation for future research.

Glossary

Table 1: Glossary of Terms

Term	Description
CEO	Chief Executive Officer
CIS	European Community Innovation Survey
CS	Consumer Surplus
DWL	Dead Weight Loss
EPO	European Patent Office
EU	European Union
FDI	Foreign Direct Investments
FE	Fixed Effects
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
ICT	In Transition Countries
IP	Intellectual Property
IPR	Intellectual Property Rights
i.i.d.	independent and identically distributed
LDC	Least Developed Country
MNC	Multinational Company
NAFTA	The North American Free Trade Agreement
NESH	The National Research Ethics Committees for Social Science and Humanities
NIPO	Norwegian Industrial Property Office
OLS	Ordinary Least Squares
OVB	Omitted Variable Bias
ρ	Intra-class Correlation Coefficient
PI	Park Index
PCT	Patent Cooperation Treaty
POLS	Pooled Ordinary Least Squares
PS	Producer Surplus
R&D	Research & Development
RE	Random Effects
SA	Saudi Arabia
SSR	Sum of Squared Residuals
TRIPS	Trade Related Aspects of Intellectual Property Rights
UN	United Nations
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

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1 Introduction

The evolution of intellectual property rights and their influence on international trade have been subject to strict academic inquiry over the years. This discussion gained renewed momentum in 1994 when The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) was established among World Trade Organization members. The agreement covers a wide array of IPRs including copyright, patent law, design law, and protection of trade secrets, and aims to harmonize the landscape of international trade by striking a balance between long-term incentives for innovation and accessibility to extant innovations in the short-term (WTO, n.d.-a).

Prior to the implementation of the TRIPS agreement, the intellectual property laws in numerous developing nations were often complex and inconsistent, which was in contrast to developed countries. Developing countries argued that stricter IPR regimes would give the developed part of the world dominance of multinational companies, creating a great debate against the stance of developed countries that cheered for the TRIPS agreement and stricter patent regimes (Deere, 2009, p. 1).

Several researchers have pinpointed that technological progress is a major source of economic growth (Griliches, 1984, p. 1). Solow (1956) claimed that technological progress is the only one. As economics students, we are interested in understanding the drivers of economic growth and innovations as they are essential and impactful parts of social and private economic value and wealth.

This study's main goal and purpose is to contribute to the existing literature on innovation-led economic development by providing policymakers and practitioners with additional insights to support their efforts in promoting innovation-driven economic growth. Patent applications can be considered a measure of innovation activity (Griliches, 1990). With regards to this and understanding of the implementation of the TRIPS agreement, we aim to measure its effect on worldwide data for patent applications.

The structure of this thesis is organized as follows: Section 2 offers a detailed presentation of our research. In section 3, we conduct a review of the most relevant literature to our area of study. Subsequently, section 4 communicate our primary hypotheses. In sections 5 and 6, we delve into the methodological framework of the quantitative approach. This includes a thorough discussion of the panel data method applied, an overview of the data sources, our selection of variables, reasoning for using the fixed effects (FE) regression models and the results. Section 7 presents a description of the chosen qualitative method, including a discussion of how an interview will be used in the overall analysis. Section 8 presents the results of the interview. Furthermore, section 9 provides a critical discussion of our findings, combining insights from the quantitative and qualitative approaches. Finally, section 10 concludes our analysis and summarizes the thesis.

2 Research Question

Our study seeks to analyze the repercussions of the TRIPS agreement on patent application trends across both developed and developing nations. To evaluate the effects of TRIPS stipulations on patent-related activities, we scrutinize the intellectual property rights laws of 68 nations spanning from 1980 to 2021. To strengthen our analysis, we employ a unique index — developed by W. Park and J. Ginarte in 1997 — that quantifies the strength of patent protection across varying nations, referred to as the Park Index. By applying the Park Index, we intend to discern the effects of TRIPS commitments on patenting applications within these 68 countries. Consequently, our research question is: Has the implementation of The Agreement on Trade-Related Aspects of Intellectual Property Rights altered the volume of patent applications from residents and non-residents in developed and developing countries?

In pursuit of answers, the thesis will delve into the nuances of the TRIPS agreement, explore the complexities of international patent applications and study the distinction of impacts between residents and non-residents and between developed and developing countries. By contributing to the corpus of knowledge surrounding the TRIPS agreement, we hope to explain the roles and dynamics of IPRs in the global economic landscape.

3 Background and Literature

To ensure trustworthy analysis and reliable interpretations, it is vital to understand the context and rationale behind the debate on the TRIPS agreement. In this section, we examine a range of key topics.

Firstly, we will explore the structure of the patent system, laying a groundwork for our discussion. Next, we assess how patents can be used as a measure of innovative activity. Then, we delve into the features of the TRIPS agreement and why it sparks so much controversy. Understanding these specifics will shed light on the key issues at hand. Following that, we consider the propensity to patent, offering insight into why and when entities choose to patent their inventions. We also compare imitation to patenting, a comparison that illustrate alternative paths to achieving business and economic goals. Finally, we investigate the relationship between Research and Development (R&D) and patenting, enriching the understanding of how invention and commercialization interact.

3.1 The Patent System

To address our research question, it is crucial to comprehend the nature of patents and the role of the TRIPS regulation. Patents serve as legal documents that grant the holder exclusive rights to manufacture, utilize, and sell an invention limited to a specific period. These rights encompass exclusive control over the distribution, production, copying, and licensing of the patented invention within the designated jurisdiction (Arza et al., 2023).

For an invention to be patentable, it must meet the following four primary criteria:

1. ***Patentable subject matter:*** The invention must fall within the categories of inventions that can be patented. Abstract ideas, business concepts and natural phenomena cannot generally be patented. The invention needs to either be a machine, a manufactured product, a composition made from two or more substances, or a process for manufacturing objects (Scotchmer, 2004, p. 66).

2. ***Utility:*** The invention should serve a functional purpose or application and should be feasible for manufacturing or utilization within a specific industry (Scotchmer, 2004, p. 68).

3. ***Novelty:*** The invention must be new. In other words, it has not been previously disclosed or made available to the public in any form. This includes any public use, sale, or publication around the world (Scotchmer, 2004, p. 68).

4. ***Non-Obvious:*** The invention has to be sufficiently different and not just a simple modification of something that already exists (Scotchmer, 2004, p. 68-69).

The primary objective of the patent system is to promote innovation and technological progress. It does so by granting inventors temporary monopolies, enabling them to profit from their inventions. Without a system that exclude competitors, innovators might struggle to earn returns from their creative efforts. This struggle could potentially decrease their motivation to innovate. As a result, society might miss out on the full potential of innovative activities, leading to suboptimal levels of innovation (Arza et al., 2023). By allowing inventors to benefit from their inventions, the patent system encourages individuals to invest in the development of new ideas, technologies, and products (Griliches, 1990). This is a key point of interest in our study.

A well-functioning patent system is viewed as a powerful driver for creativity, technological progress and economic development. However, significant societal advantages can be severely diminished by poorly designed systems that result in issues such as subpar patent quality and increased uncertainty (Hall, 2007). One mechanism for enhancing the functionality of patent systems is the implementation of a post-grant review process for patent quality (Winston & Strawn LLP, n.d.).

3.2 Patents as a Measure of Innovation Activity

We aim to use patent statistics as measures for the output of innovation activities. However, it is essential to recognize that a patent represents only a fraction of inventions. They have undergone rigorous scrutiny by the patent office, considering factors such as their significance and the resources invested by the inventors throughout the development process. This implies that patents carry not only utility but also substantial non-negligible expectations of marketability. It is worth noting that not all inventions can be patented, not all patented inventions are equally valuable, and the quality of patented innovations varies considerably (Griliches, 1990).

On the other hand, patents have been used as an indicator of innovative activity, focusing on their role as an input rather than an output (Griliches, 1990). Inventive activity can be defined as "work specifically directed towards the formulation of the essential properties of a novel product or process" (Schmookler, 1966, p. 8). This concept is closely linked to R&D expenditures, which serve as inputs for innovation development. The success of innovation is associated with the anticipated economic gains for the innovator. Consequently, if the expected benefits from patenting outweigh the costs associated with it, the innovator is more likely to apply for a patent. Thus, the number of patents can be viewed as an indication of successful projects (Griliches, 1990).

Griliches' study generated several significant findings. One notable observation was the strong correlation between patent grants and R&D expenditures at a cross-sectional level. This suggests that patents serve as a reliable indicator of variations in inventive activity across different firms (Griliches, 1990). When considering the cross-sectional level, smaller firms appear to be more "efficient" as they receive a higher number of patent grants per dollar spent on R&D, although the significance of this finding varies across research studies (Griliches, 1990). Furthermore, smaller firms tend to engage in more informal R&D and may report fewer R&D expenditures, yet they generate a greater number of patents relative to their R&D investment (Griliches, 1990).

3.3 The TRIPS Agreement

The TRIPS agreement, established in 1994, is an international agreement among members of the World Trade Organization. Therefore, all WTO members must adhere to these standards. It governs trade-related aspects of intellectual property rights and covers areas such as copyright, patent law, design law, and protection of trade secrets (Willis, 2013). The objective of TRIPS is to create a balance. On one hand, it aims to foster long-term incentives for innovation. On the other, it wants to facilitate access to existing innovations in the short term (WTO, n.d.-a).

The agreement has several key provisions. It mandates a minimum patent duration of 20 years. It also requires the acceptance of patents in all fields. Moreover, it prohibits discrimination based on the location of the invention or the product's origin. Lastly, it assigns the burden of proof to the accused party in suspected patent infringement cases (Arza et al., 2023).

The TRIPS agreement was created as supplement to the General Agreement on Tariffs and Trade (GATT). This is an intergovernmental pact focusing on tariffs and trade, serving as a platform for international trade negotiations from 1947 to 1994. It offered a structural framework for member nations. This allowed them to negotiate trade agreements efficiently.

Furthermore, the WTO, established through the Marrakesh Agreement marked a substantial transformation in international trade regulation. Unlike the GATT, which was a set of mutually agreed-upon rules, the WTO serves as an institutional body. Its purpose is to supervise the execution and functioning of the agreement, adjudicate trade disputes, and host trade policy review forums. The WTO's reach is more extensive than that of its predecessor, the GATT. While both focus on trade of goods, the WTO further addresses trade services and intellectual property rights. The inclusion of these additional areas reflects the changing landscape of international trade, highlighting the comprehensive approach of the WTO (WTO, n.d.-c). In essence, the establishment of the WTO and the shift in its regulatory approach significantly broadened the scope of international trade policy and dispute resolution mechanisms.

TRIPS emerged in response to the need for a robust framework to address non-tariff barriers to trade, particularly related to intellectual property rights (Willis, 2013). It was formulated during the Uruguay Round, the eighth round of multilateral trade negotiations under GATT which began in 1986 and concluded in 1994 in Marrakesh (United Nations, n.d.).

While the TRIPS agreement was seen as a victory for multinational companies seeking stronger protection of their intellectual property in developing countries, it faced opposition from many developing nations. These countries argued that the agreement would reinforce the dominance and ownership of multinational corporations over their ideas, widen the technology gap between the global North and South, and accelerate the capital transfer to developed nations. They also expressed concerns that stricter intellectual property standards would hinder their development (Deere, 2009, p. 1).

In the situation preceding the implementation of the TRIPS agreement, the intellectual property laws within many developing nations were often complex and inconsistent. This legal landscape posed significant challenges for innovators striving to secure their intellectual property rights internationally. In addition, many of these countries were compelled to maintain standards that surpassed those mandated by the GATT. The absence of robust patent and copyright laws within these nations presented a hurdle for creators in securing their intellectual property. Developed nations could potentially exploit this scenario by appropriating the intellectual property of developing countries (Revesz, 1999). This implies that due to weak intellectual property protection, developed countries might have been able to use, reproduce, or benefit from the intellectual creations originating from these developing nations without providing fair compensation or acknowledgment.

To rectify these problems, the TRIPS agreement was introduced, setting a universal baseline for the protection and enforcement of IPRs that all WTO member countries are obligated to adhere to. Consequently, numerous countries enhanced their intellectual property frameworks, thereby promoting greater uniformity and efficacy in their protection mechanisms (Revesz, 1999).

3.3.1 A debate on the TRIPS Agreement and Strong IPRs

The roll-out of TRIPS sparked a worldwide debate on IPRs and development. It underscored the vulnerability of developing nations to the influence of their more powerful and developed counterparts. This highlighted the need for more fair and effective global economic regulations (Deere, 2009, p. 1-3). In light of this, we will further examine and present various perspectives on the TRIPS agreement.

Pro TRIPS arguments

The TRIPS agreement brings stricter regulations of intellectual property rights. This can provide firms with ownership advantages, such as gaining a competitive edge by controlling patents (Hassan et al., 2010). Such advantages can motivate firms to invest in countries with robust IP protection. The strict IPR rules can minimize the risk of unauthorized copying, which can lead to increased demand for protected products (Primo Braga & Fink, 1998).

In addition, firms can save costs associated with safeguarding their knowledge assets. This may foster bilateral exchange and increase market penetration in foreign economies. Thus, strengthening IPR could promote positive trade outcomes (Maskus & Penubarti, 1995). Firms from developed nations may have significant ownership advantages. These advantages can encourage them to transfer technology to developing countries through trade, foreign direct investment (FDI), or licensing (Hassan et al., 2010).

Strong IPRs can notably affect the volume of FDIs and impact the investment decisions of multinational companies. Developing countries with stronger IP protection may gain what we term "location advantages". These advantages refer to the benefits a company gets due to specific geographical or jurisdictional characteristics, especially those related to the protection and enforcement of IPRs. Such location advantages can sway a company's investment decisions. A firm might decide to invest in a particular country or region based on these advantages. Furthermore, it might influence the jurisdiction a company selects for patent filing. Therefore, the presence of strong IP protection can have a positive impact on multinationals' investment decisions (Primo Braga & Fink, 1998).

However, countries with weak IP protection may appear less attractive to foreign firms. If these countries improve their IPR frameworks, they may increase their appeal as investment destinations. This can incentivize multinationals to improve the quality of their investments in developing countries (Hassan et al., 2010).

The TRIPS agreement aims to harmonize intellectual property rights, which can reduce the costs of trading goods and services across different legal systems. Harmonization can reduce transaction costs such as legal fees and R&D expenses by eliminating the need for companies to adapt to diverse IPRs across countries. By adopting international IPR regulations, countries may achieve cost-effective international trade and gain location advantages (Hassan et al., 2010).

Even though Primo Braga & Fink (1998) couldn't confirm a clear link between Foreign Direct Investment and Intellectual Property Rights decisions, strong IPRs may foster both location and ownership advantages. This idea supports the arguments made above. Stricter IPRs can offer an ownership advantage for firms that patent their work. The desire for control over innovations and stronger IP protection in certain jurisdictions can incentivize such firms. However, one should proceed with caution as ownership advantages can lead to monopolistic situations and possible economic losses. More on this will be discussed in the upcoming section about criticisms of the TRIPS agreement.

The TRIPS agreement also takes into account the financial conditions of WTO member countries. This is done by acknowledging their development levels, technological capabilities, and administrative capacities. With transitional arrangements (Part VI of the agreement), developing countries get extra time for compliance. As developed countries had to comply within January 1st 1996, developing countries got four additional years, and least developed countries even longer (Willis, 2013).

The TRIPS agreement allows flexibility in interpreting its diverse articles. For example, Article 27.3 lets countries exclude certain innovations from patentability and protect others. Developing countries also maintain the right to import or issue compulsory licenses for pharmaceutical products during emergencies. This provision has been crucial in managing public health crises related to Malaria and HIV/AIDS (WTO, 2001).

The TRIPS agreement marks a significant step forward from previous IPR regulations. It improves dispute resolution, monitoring, and enforcement (Matthews, 2002). The TRIPS Council reviews national legislation and supervises the agreement's implementation. If major disputes arise, any member country can bring its case to the WTO Dispute Settlement Body, which has the power to enforce compliance using trade sanctions. The dispute resolution mechanism has proven effective in developing countries, as evidenced by cases involving disputes between Ecuador and Brazil (Willis, 2013).

Further, intellectual property rights can help reduce information imbalances in technology transfer contracts (Hassan et al., 2010). In these contracts, the seller often knows more about the technology than the buyer. This information gap can hinder agreement on a price that reflects the technology's true value. Fear of losing negotiating power or creating competition may also prevent the seller from sharing information. As a result, many beneficial technology transfer deals may not materialize. So, strengthened IPRs might reduce information asymmetry, facilitating technology transfer agreements (Hassan et al., 2010).

Lastly, the TRIPS agreement can promote global economic stability through improved IPR regimes. With consistent regulations and robust monitoring programs, trust in the patent system may increase. This can stimulate investment in innovation, particularly in developing countries where regulatory changes can have a more profound impact.

Critique of the TRIPS agreement

Even though many praise the TRIPS agreement for its benefits, it also get plenty of criticisms. We dive into these arguments, discussing the factors that make them important and examine why a less stringent approach to IPRs might be better under certain circumstances.

In less wealthy economies, companies usually struggle to assign much resources to research. This becomes even tougher under strict patent rules. Why? Patents usually require heavy R&D spending, which can especially strain firms in developing countries (Park, 2008). High patenting costs may hinder strategies for imitating innovations. This can reduce the spread of technology within developing nations (Arza et al., 2023).

Furthermore, developing countries usually have limited capabilities to absorb knowledge, such as human capital. This means that their innovation investments may yield smaller returns. Therefore, the possible benefits of patents in encouraging innovation might be offset by negative effects on technology adoption and imitation. This can result in that stricter IPR regimes, caused by TRIPS, being less effective in developing nations (Sweet & Maggio, 2015).

Expanding on this, the benefits of stricter IPRs depend on factors like innovation capabilities and market size. Developed economies, usually with larger markets and greater wealth, can capture more of the worldwide returns from innovation. This means that their ideal IPR level might generally be higher than that of less developed countries. Consequently, it may be more beneficial for developing nations to prioritize the augmentation of their innovative capacities and strive for alignment with the global innovation frontier before fostering suitable domestic environments for innovation. This view questions the logic behind international IPR harmonization, considering the unequal opportunities for countries to benefit from patents (Grossman & Lai, 2004).

The impact of the TRIPS agreement on the health sector, especially in developing nations, sparks a great debate. Critics argue that IPR protections have hindered access to affordable, essential medicines in these areas. Many believe there should be a distinction between medicines for non-life-threatening conditions and those vital for treating severe diseases like AIDS or specific antibiotic-resistant infections (Subhan, 2006).

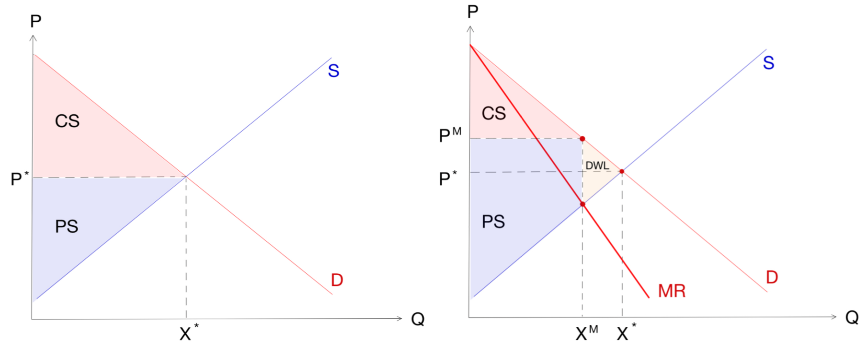
The COVID-19 pandemic has actualised the above mentioned debate. The uneven distribution of vaccines underscored the limitations of the TRIPS agreement's flexibility, with developing nations facing severe shortages compared to wealthier countries (Tatar et al., 2022). Although the TRIPS agreement does allow for some flexibility, such as compulsory licensing and temporary waivers (WTO, 2020), these provisions did not guarantee fair vaccine distribution. Several countries and pharmaceutical companies objected to the waivers, expressing concerns about innovation and IPRs. This resistance made it even harder for developing countries to access vaccines (Buford-Young, 2022). In conclusion, the COVID-19 crisis highlights the practical limitations of the TRIPS agreement. Despite its built-in flexibilities, various hurdles can lead to less effective results than initially planned.

Regarding resource allocation, an interesting argument arises: by nature, knowledge is a collective good, as it is non-rivalrous and non-excludable (Hesse, 2002, p. 26-45). Unlike physical assets, knowledge does not lose value no matter how widely it is shared. One person's use of knowledge does not prevent others from accessing or using the same knowledge. However, the introduction of intellectual property rights creates a sense of "artificial" scarcity (May & Sell, 2006, p. 17-20). This enforced scarcity is designed to protect and encourage innovation. But, it also calls for a balance between private ownership and communal sharing of intellectual property (Willis, 2013).

Enhanced IPRs provide the owners increased market power due to provisional monopolies. When a corporation exerts such market power, it can lower the elasticity of demand for its patent-protected product within the destination country. As intellectual property rights shield distinctive goods or methods, typically there are limited or no immediate alternatives. With fewer replacement options, consumer choice decreases, which results in demand becoming less responsive to price variations. This can lead to increasingly inelastic demand. Also, it can lead to a reduction in investment or production in the host country as the market becomes smaller, in addition to less trade and reduced bilateral exchange (Maskus & Penubarti, 1995). Furtherore, as foreign firms can charge higher prices due to higher IPR protection and lower competition, the cost of transferring technology might increase.

Figures 1 (a) and (b) provide a visual interpretation of the effects heightened IPR protection can have on price and quantity in a simplified linear model. The x-axis illustrates the quantity of goods, while the y-axis represents the price. The downward-sloping demand curve (D) signifies the relationship between price and the quantity that consumers are willing to purchase. The upward-sloping supply curve (S) indicates the relationship between price and the quantity that producers are willing to supply. Furthermore, the consumer surplus (CS) is shown in the red area below the demand curve and above the equilibrium price. The producer surplus (PS) is shown with the blue area above the supply curve and below the equilibrium price. Both the CS and PS are limited by where the supply and demand curve meet.

In situations where IP protection intensifies, leading to temporary monopolies, foreign companies gain the capability to set prices above marginal costs. This situation leads to the creation of deadweight losses within economies (a welfare loss for the society) illustrated by the orange area in Figure 1 (b). As a consequence, the demand curve shifts downwards and is shown with the marginal revenue curve (MR). The shift triggers a movement of the equilibrium point — where demand meets supply — resulting in a decrease in quantity demanded (from Q^* to Q^M) at an increased price (from P^* to P^M). The region captured between the original and the shifted demand curves represents the higher prices charged by monopolistic firms, marking the deadweight loss (DWL). Also, as the equilibrium changes, the consumer surplus reduces and the producer surplus increases (Hassan et al., 2010). This loss embodies the market inefficiency triggered by the monopoly that arises from a stricter IP protection regime.



(a) Market with Perfect Competition (b) Market with Monopoly

Figure 1: Monopolies Create a Dead-Weight Loss in the Economy

The argument that strict IPR regulation reduces information asymmetry hinges on the assumption that certain knowledge, being so-called tacit and complementary, must be transferred in tandem with codifiable knowledge. However, this perspective neglects the significant legal and technical capacities required by the recipient nation. These capacities necessitate a highly skilled workforce capable of navigating intricate contract negotiations. As a result, many developing countries have pursued non-market channels for technology transfer, such as imitation, during periods characterized by weak IPR regulation and compliance. The strategic use of weaker IPRs has been employed as a mechanism to stimulate industrial development within these nations (Foray, 2009).

3.4 The Park Index

The Park Index is used to analyze the impact of the TRIPS agreement on patent applications. This allows us to analyze the influence of the increased IPR protection brought about by the TRIPS agreement on the number of patent applications.

The Park Index, initially developed to cover 110 countries from 1960 to 1990 (Ginarte & Park, 1997) has since been extended to 2015. It evaluates the strength of patent protection at the national level. The Park Index consists of five main elements: the extent of the laws, participation in global patent agreements, provisions for protection loss, enforcement mechanisms and the length of protection. Each element scores from 0 to 1. The final index value is the sum of these scores giving values between 0 and 5. A higher index value signifies stronger patent protection. Each category contributes equally, accounting for one-fifth of the total score (Ginarte & Park, 1997).

Table 2 shows an example of how to calculate the Park Index, using Norway's 1995 score as an illustration.

Table 2: Norway's Park Index Score Computation in 1995

Component	Score	Weight
Coverage	0.63	1/5
Membership	1.00	1/5
Loss of Rights	0.33	1/5
Duration	1.00	1/5
Enforcement	1.00	1/5
PI score (sum)	3.96	1

The five elements of the Park Index can be assigned varying weights based on their perceived significance. For instance, some may deem the provision for loss of protection as being more important than others. Such differential weighting might be particularly relevant for innovators with diverse needs (Ginarte & Park, 1997). Nevertheless, Ginarte and Park's research suggests that the rank sensitivity is low even when the components are assigned different weights (Ginarte & Park, 1997). For the purpose of our analysis as outlined in the preceding paragraph, we use the PI scores where all components are considered equally significant, each contributing one-fifth to the total score.

The implementation effect of the TRIPS agreement can be measured by an increase in the Park Index. This is due to the fact that various nations adopted TRIPS at different times, based on their developmental status (WTO, n.d.-b). By incorporating variables that varies over time and reflect the evolution of index values for each country, we can determine how an increase in the index and the implementation of TRIPS impact patent applications.

3.5 Propensity to Patent

Patents offer inventors protection for their inventions over a limited period of time but require the disclosure of their technical details to the public. Alternatively, a company can choose to keep the specifics of the invention as a trade secret, thus avoiding disclosure. However, by taking this route, the company disclaims legal rights to prevent competitors from using the invention (Mosel, 2012).

Changes in intellectual property laws can intensify international competition. Additionally, the emergence of numerous new technologies suggests that patents might be more valuable than secrecy for many innovative companies. This seems particularly apparent for smaller firms that do not have the resources to gain market dominance. The significance of patents has amplified since the 1980s, leading to a transformation in business strategies to favor more patenting. This trend can be due to an increase in patent propensity rates, meaning more innovations are seeking patent protection. An alternative reason can be a heightened effort to fully exploit the potential of patents through various strategic approaches. Most likely, it is a combination of both of these factors (Arundel, 2001).

Concerns have been raised regarding the increase of patents, with some suggesting that the fall in European firms' competitiveness may be related to underutilized patents used to shield innovation investments. In response, European Commission policymakers encourage more patenting, particularly by smaller enterprises. However, these policy suggestions often miss why companies might opt for alternative protection methods like secrecy (Arundel, 2001).

Arundel (2001) did an analysis with data from the 1993 European Community Innovation Survey (CIS) for 2,849 R&D-performing firms to see the relative importance of secrecy vs. patents. He found that a higher percentage of firms of all sizes find secrecy a more effective way of protecting their innovation than patents. Also, firms that rated secrecy as a more effective method than patents had a lower propensity to patent product innovations than those who found secrecy ineffective (Arundel, 2001).

Mosel (2012) uses data from the 2004 CIS to study the relationship between a firm's propensity to patent and the size of the invention. The analysis focuses on whether firms lean towards the "traditional view" - viewing patents as the primary means of protecting IP, or the "strategic view" - favoring secrecy as the best way to safeguard their innovation. Mosel found that in countries with strict patent rights, firms often adhere to the traditional view. Conversely, in countries with weaker patent rights, firms tend to avoid patenting smaller innovations primarily because of the associated patenting costs. Patents are not sought for major innovations due to fear of disclosure of knowledge and imitation. However, for medium-sized innovations, firms tend to seek patents to gain an advantage, especially given that multiple firms can simultaneously discover the same innovation (Mosel, 2012).

Arundel's 2001 study presents intriguing findings, sparking curiosity about whether these patterns persist in times after the TRIPS agreement was implemented. Newer research, notably Mosel's work from 2012 suggests an increase in both the significance of patents as a protective measure for innovations and the tendency to seek patents. This shift might be a consequence of the TRIPS agreement, making us curious about how patent applications trend post-TRIPS implementation.

3.6 Imitation and Patents

Mansfield (1981) revealed several significant findings regarding the costs and impacts of innovation and imitation. He discovered that the costs of imitating an innovation were on average nearly two-thirds of the original innovation costs (Mansfield et al., 1981). Another surprising finding was the frequency of imitation for patented innovations, with 60 percent being imitated within four years of their initial launch. Mansfield's study further showed that less than a quarter of patented innovations in industries other than pharmaceuticals would have been developed without the safeguard of patent protection. Additionally, in several prominent industries, innovations that led to decreased market concentration represented a significant proportion of all product innovations. These findings shed light on the intricate dynamics of innovation, imitation, and patent protection across various industries (Griliches, 1984, p. 5).

3.7 Strong IPR Regimes and Licensing

Stronger IPRs can encourage multinational corporations (MNCs) to license their innovations rather than produce them directly abroad (Primo Braga & Fink, 1998). Research has shown that stronger IPRs do indeed boost licensing (Hassan et al., 2010), which allows MNCs to increase their profits from their intellectual assets. This can be done without the hassle and costs of running manufacturing operations overseas (Arora et al., 2001). Furthermore, licensing can be a cost-effective way for MNCs to present their innovative products in international markets (Arora & Fosfuri, 2003). This approach reduces expenses by avoiding the large capital investments, labor costs, and regulatory requirements that come with operating foreign production facilities (Smith, 2001).

Ferrantino (1993) finds that increased IPR protection increases the volume of licensing considerably, appearing as a substitute for trade. In the case of stronger IPRs, licensing may have a negative effect on trade flows (Hassan et al., 2010). Conversely, if a country has weak IPR, the company may prefer FDI since they are able to have better control over their technology through internalized foreign production or in-house foreign R&D (Ferrantino, 1993).

3.8 The Relationship Between R&D and Patents

Griliches has shown that there is a strong relationship between the number of patents granted and R&D investments. This induces that using patents might be a great indicator of unobserved inventive output (Griliches, 1990). These findings were released in 1990, prior to the implementation of the TRIPS agreement. As a result, it may be interesting to study how this relationship evolved after TRIPS implementation. Further, we study whether the relationship between patent applications and R&D spending is similar to what was previously discovered for the association between patent grants and R&D expenditures. We will come back to this later.

There are two requirements for R&D to arise as an organized activity: the (1) ability and (2) incentives to fund research. One needs the ability to invest in and fund research, requiring resources and control. Examples are governments with the ability to tax organizations and the society's usage of resources and private concentrations of wealth. Incentives to fund research can occur in many forms. Governments' incentives can appear as a legitimate part of their assignments and missions if research leads to comprehensive benefits for the citizens. Seen from the view of wealthy individuals and non-governmental organizations, incentives to invest in R&D can appear due to several reasons. For instance, an incentive can be built on philanthropy (Scotchmer, 2004, p. 2), the wish or desire of improving human welfare (Adam, 2022). Wealthy individuals can also have incentives like curiosity, a wish for recognition and commercial reasons (Scotchmer, 2004, p. 3).

R&D has always been driven and encouraged by governments and wealthy individuals, but intellectual property, the main means of acquiring benefits was developed later in newer eras. The latter is developed by governments shaping commodity standards that only apply to new innovations (Scotchmer, 2004, p. 3).

Both R&D spending and patents may be used to assess innovation activity since R&D investment is expected by researchers to result in more patents. One can look at R&D spending as a measure of inventive inputs, while patents and other IPRs are measures of inventive outputs. The point under consideration is whether data on patents can contribute to our understanding of the effects of R&D spending on growth and consumer welfare (Scotchmer, 2004, p. 270-271). An examination of the relationship between R&D investment and patent grants reveals that domestic patent grants have dropped as a percentage of RD and GDP during the majority of the century, with an increase in patents in the US in the 1990s (Scotchmer, 2004, p. 272).

Patent grants recover a small portion of RD spending as profit. The reason is that the inventors have other options for the protection of their innovation, e.g., trade secrets (Scotchmer, 2004, p. 259-260). It is therefore important to distinguish between the value of an invention and the value of a patent (Scotchmer, 2004, p. 282).

Furthermore, the correlation between patent applications and R&D can also be influenced by the productivity of R&D (Griliches, 1984, p. 5). It is conceivable that developing nations may exhibit relatively lower R&D productivity compared to their developed counterparts (The World Bank, n.d.-d). As a result, residents of developing nations might not possess the ability to fully exploit the resources allocated for research and development. This can lead to a reduction in patent applications emerging from these countries. Therefore, the relationship between patent applications and R&D may vary between the developed and developing regions of the world.

4 Hypothesis Building

We aim to investigate two hypotheses. First, we hypothesize that the TRIPS agreement has boosted patent applications from non-residents in developing countries while not enhancing resident applications. Second, we hypothesize that the same agreement has spurred a relatively larger increase in resident versus non-resident patent submissions in developed nations. These will be further underpinned and discussed.

4.1 Hypothesis 1 - Developing Countries

Several studies suggest that stricter intellectual property (IP) regulations in developing nations may not actually encourage innovation within their borders. Although these regulations appear to increase the total number of patent grants, it seems that this increase is mainly driven by filings from non-residents rather than residents. However, these studies often focus on different levels of IP protection without specifically examining the impact of the TRIPS reform.

When studying the effects of TRIPS, researchers often overlook the TRIPS compliance dates for each country (Arza et al., 2023). Therefore, it can be valuable to incorporate a variable that accounts for the year when each country implements the 20-year patent length rule, a crucial compliance criterion for the TRIPS agreement. This compliance variable is closely related to the "duration" component of the Park index, which measures the same concept. Therefore, we cross-check our findings for these years with Park's work. This will be discussed later. By including such a variable, we can more effectively evaluate how the specific regulatory changes resulting from TRIPS influence patent applications in developing and developed countries (Arza et al., 2023).

TRIPS' stronger intellectual property rights (IPR) protection can heighten patent acquisition and enforcement costs. It also raises the concern of foreign firms dominating the market and impeding local innovation. It may also hinder residents in developing countries from leveraging intellectual property for economic and technological growth (Arza et al., 2023). Market sizes and wealth levels can potentially affect innovation and patent activities (United Nations, 2014). In general, countries with larger GDP are more developed. Despite this, resource constraints are more common in developing nations (Park, 2008). These limitations may indicate that stricter patent regimes discourage local innovation due to scarce resources for enforcing these systems and fostering innovation, leading to little or no change in patent applications from residents.

Enhanced patent protection can create stability and security in developing nations. This might attract foreign investors. Improved investment climates can enable technology transfer from developed to developing countries through various channels like trade, direct investment, or licensing (Hassan et al., 2010). Thus, non-resident patent applications in developing countries may rise.

In light of the preceding discussion, we formulate the first hypothesis as follows: *The implementation of the TRIPS agreement results in increased patent applications from non-residents and no growth in patent applications from residents in developing countries compared to the pre-TRIPS period.*

4.2 Hypothesis 2 - Developed Countries

More developed nations often have well-established systems for knowledge spreading and information accessibility (Grossman & Helpman, 1994). They often implement strict patent regimes earlier, which is evident from the evolution of Park Index values. The most recent update of the Park Index was received from our supervisor, Per Botolf Maurseth, on February 10, 2023, and later from Walter Park via email on May 26, 2023 (full version attached). Therefore, residents of these countries are well-positioned to comprehend the intricate patent filing processes and appreciate the benefits. Such an elevated understanding can potentially trigger a rise in resident patent applications in developed countries.

As outlined in the literature, the ability to fund research is a crucial prerequisite for technological advancement, innovation creation (Scotchmer, 2004, p. 2) and subsequent patent filing. This becomes particularly challenging for firms in developing countries, often marked by limited wealth and resource constraints. Their capacity to commit substantial resources to research and development becomes increasingly difficult in the face of strict patent regimes that necessitate additional R&D expenditures associated with patents. In comparison to their counterparts in developed nations, these firms may experience heightened restrictions due to the increased costs tied to patent applications (Park, 2008). Therefore, the financial hurdle of patent filing in developed countries is more pronounced for firms in developing countries.

Contradictory, residents in developed countries, characterized by greater wealth and resources, are likely better equipped to handle the costs of implementing stricter IPR regulations under the TRIPS agreement. It is important to note that non-resident applications encompass applicants from both developed and developing countries and that resident applications are only from the developed country. Therefore, our second hypothesis states: *The implementation of the TRIPS agreement in developed countries induces a more pronounced percentage increase in resident patent applications than in non-resident submissions.*

The North-South model also offers an insightful framework for understanding the rationale behind our hypothesis for developed countries. The model outlines a unique distribution of innovation creation between developed ("North") and developing ("South") regions. In the northern hemisphere, firms are often advantaged by robust infrastructure and ample resources, which fosters an environment contributing to innovation. As a result, they generate a multitude of novel products. Conversely, firms in the southern hemisphere primarily concentrate on imitating existing products by employing well-established production techniques initially crafted in the north. These differences trigger a product life cycle in international trade, characterized by the North's initial production and exportation of innovative goods. As these production techniques gradually become common knowledge, the manufacturing mantle is passed to the South (Grossman & Helpman, 1994).

The TRIPS agreement's strengthening of intellectual property rights can potentially stimulate innovation in the North - the developed countries - possibly leading to a surge in resident patent applications. In this regard, the application of the North-South model to investigate the dynamics between developed and developing countries supports the hypothesis that resident patent applications in developed countries may see a greater post-TRIPS increase than non-resident ones.

5 Quantitative Method: Panel Data Model

This study employs a panel data methodology, chosen for its efficiency in tracking changes over time and differences among diverse groups. We use Stata, a well-known statistical software program, to analyze the effect of TRIPS implementation on patent applications, taking into account both fixed and random effects (RE and FE) modeling. This empirical investigation will enhance our understanding of the underlying mechanisms that drive innovation.

Panel data consists of observations of specific units over time. In our study, this is annual observations of each country's patent applications from 1980 to 2021. These applications will be divided into applications for developed and developing countries, from both residents and non-residents. Panel data regressions can capture variations over time within a specific country (Cameron et al., 2010, p. 235). Additionally, it is essential that the data for each unit to be collected at consistent intervals (Mehmetoglu & Jakobsen, 2017, p. 228).

A panel refers to a sample that captures the over-time development of variables, providing multiple measures of a unit at different points in time. This introduces a longitudinal dimension to the data, allowing for the observation of changes and trends. On the other hand, cross-sectional data lacks this temporal aspect as it represents a single point in time, therefore not providing the same insight into developments over time. Further, one advantage of panel data is that when measuring units over time, the causal analysis becomes more trustworthy than cross-sectional data (Mehmetoglu & Jakobsen, 2017, p. 228). This is a part of our motivation for choosing to work with such panel data. Additionally, when having panel data compared to times series, one has the individual (here country) as the unit of analysis instead of the time points (Mehmetoglu & Jakobsen, 2017, p. 228).

The data from each time period are nested when using panel data, meaning that each unit's observations depend on each other (Mehmetoglu & Jakobsen, 2017, p. 228). This violates the Ordinary Least Square (OLS) assumption of independence and is a characteristic of panel data analysis, called intraclass correlation (Mehmetoglu & Jakobsen, 2017, p. 228). Therefore, the panel data estimators' standard errors must be adjusted for this (Cameron et al., 2010, p. 235).

When using panel data methods, one should also control for unobserved explanatory variables. As panel data assumes that the units are heterogeneous, not controlling for this may result in biased results. Hence, controlling for individual heterogeneity through measuring units over time with different control variables puts one in a better position to account for such unmeasured variables (Mehmetoglu & Jakobsen, 2017, p. 229). We will discuss these aspects below.

5.1 Balanced and Unbalanced Data

A panel dataset can be either balanced or unbalanced. Having balanced data means that all individual units are observed in the same time period (i.e., years) as the others ($T_i = T$, for all i). Having unbalanced means the opposite, i.g., country i is only observed in 39 years, simultaneously as the remaining countries are observed in 40 ($T_i \neq T$, for all i) (Cameron et al., 2010, p. 236). Ideally, we prefer to have a balanced dataset, as it makes the analysis more complete.

Panel data commands (i.e., xtregress in Stata) can be applied to both balanced and unbalanced data. However, caution should be exercised when dealing with significant attrition rates. Attrition, the progressive loss of data points or observations over time, can pose challenges. This is frequently encountered in longitudinal studies due to participant dropouts, non-responses or loss of follow-up (Mehmetoglu & Jakobsen, 2017, p. 229). In this context, attrition may arise when some patent application values are not universally available across all periods. For example, certain countries might cease to report patent statistics, or nations may dissolve (e.g. the resolution of the Soviet Union).

When attrition rates are high, it can result in unbalanced data characterized by missing data points for specific periods or units. Crucially, the process of data attrition is often non-random and can be systematically linked to other data attributes. Consequently, the outcomes of any analysis can be skewed, failing to accurately represent the subject under study and potentially replicating biased results. Thus, handling high attrition rates responsibly is vital for ensuring the integrity of the results (adapted from Mehmetoglu & Jakobsen, 2017, p. 231).

However, several reasons exist to avoid making a balanced selection since most panel-data methods can handle unbalanced data. Modifying a dataset to become balanced will limit and refine the data set unreasonably. For example, if we remove the years or the countries where we have missing values, we will lose information, and we cannot ensure that the years or countries we keep are representative (Ringdal & Wiborg, 2022, p. 241).

5.2 Selection of Data Sources & Data Modifications

The data used for this panel data analysis is predominantly taken from databases managed by the World Intellectual Property Organization (WIPO)[1] and the World Bank's World Development Indicator database[2]. The direct link to the data for all specific variables used in our dataset is attached.

Key variables used in our study encompass the total number of patent applications submitted to each country and are derived from WIPO. The data on resident and non-resident applications, Gross Domestic Product, Gross Domestic Product per capita, export and import volumes, and Research and Development expenditures were extracted from the World Bank's World Development Indicators database. Hence, it is worth noting that distinct sources is used for resident and non-resident data compared to the total application data. As a result, potential discrepancies in data registration may occur, leading to instances where the sum of resident and non-resident applications does not align perfectly with the total number of applications.

We face difficulties due to incomplete data for some countries leading to an unbalanced dataset. To address this, we corresponded with Per Ødegård, a Senior Adviser for Communication and Knowledge at the Norwegian Industrial Property Office (NIPO), through emails on February 21st and March 9th. Ødegård provided the missing Norwegian patent data for the years 2002 to 2006, which was missing from the WIPO database, thus partially filling the data hole.

Nonetheless, other obstacles persist. For example, there are missing data for Algeria's patent applications in 2008 and 2009. We do not manage to find this data. Given the substantial number of Algerian applications both pre- and post-data the gap, we conclude that this absence is probably due to recording oversights rather

[1]https://www3.wipo.int/ipstats/index.htm?tab=patent
[2]https://databank.worldbank.org/source/world-development-indicators

than a lack of patent applications. To resolve this, we opt for a weighted average of the application counts from the two years preceding and following the data gap to estimate the missing values, as presented in equation (1).

$$\text{Appl. Value in year t} = \frac{1}{4}\left(\sum_{i=-2}^{-1} \text{Appl. Value}_{t+i} + \sum_{i=1}^{2} \text{Appl. Value}_{t+i}\right) \quad (1)$$

In our methodological approach, we have developed a guideline for handling data gaps spanning five years or less. This guideline calls for the use of weighted averaging to fill in missing data points in order to reduce biases in our trend analysis over time. Such biases may arise due to over- or under-estimation of values. In scenarios where the data for multiple consecutive years is unavailable, we adopt a consistent approach by assigning the same weighted value to each of these years. This approach is illustrated by the blue-highlighted figures in Table 3 below. It is crucial to mention that the use of weighted values results in decimal figures, as opposed to the whole numbers typically observed in real-world data. This is a notable deviation from usual data patterns.

Table 3: Computation of Missing Data for Patent Applications

Year	Country	Applications	Grants
2006	Algeria	669	479
2007	Algeria	849	214
2008	Algeria	805.25	246
2009	Algeria	805.25	618
2010	Algeria	806	1076
2011	Algeria	897	1546

We consider estimating the missing data based on the trend of increase or decrease in the available real data. However, we dismiss this approach due to its unreliable nature, especially when a clear trend is absent in the data. For instance, the data for applications in Algeria between 2007 and 2010 shows a decreasing trend, but a significant increase is observed in 2011. Consequently, we believe that the use of a constant weighted value (805.25) for the missing values provides a more accurate result.

Incorporating the Park Index data into our dataset pose a challenge due to the index being updated every fifth year. Rather than allowing data gaps in the intervening years, we choose to estimate values for those years throughout our dataset's timeline. We chose to do so since the missing index values are caused by missing estimations rather than a lack of patent protection.

The index appears to increase over time in general. As a consequence, we define a variable called ”PIcon” to account for this in our study. This variable represents how the index is growing over the years and will be described in detail later. For instance, this method led to an increase between 1995 and 2000 for Algeria and no change in the estimates when the index remained constant. This is evident from the blue-highlighted estimated values in Table 4. In a few instances where the index decreased, for example, from 2005 to 2010, we gradually reduced the values for the intervening years. Consequently, our estimates reflects the temporal changes in the index values.

In general, the index has a tendency to increase over time. To account for this trend in our study, we include a new variable called ”PIcon” that indicates the index's growth over time. The variable name ”PIcon” relates to the Park Index's constant replication, which means we have estimated values for each year. For example, we noticed an increase in the data from 1995 to 2000 for Algeria, leading to constant growth between these years. We kept the same estimations when the index was stable, as shown by the blue-highlighted numbers in Table 4. When the index decreases, as it did from 2005 to 2010, we gradually lower the values for the years in between. As a result, our calculations appropriately reflect the index's year-to-year variations.

Table 4: Computation of Missing Estimated Data for the Park Index

Year	Country	PI increase
1990	Algeria	2.45
1991	Algeria	2.45
1992	Algeria	2.45
1993	Algeria	2.45
1994	Algeria	2.45
1995	Algeria	2.45
1996	Algeria	2.49
1997	Algeria	2.53
1998	Algeria	2.57
1999	Algeria	2.61
2000	Algeria	2.65

5.3 Variables

In this section, we introduce and discuss the variables used in our analysis. The variables are classified into two main categories: explanatory variables and control variables. Explanatory variables are the primary factors that we expect to predict the outcome variable. They are the primary focus of our analysis and our hypothesis testing. These variables are carefully selected based on theoretical relevance, as well as prior research findings. Control variables, on the other hand, are not the main focus of our study but are included in the model to account for potential confounding factors. These factors may also influence our outcome variable, and by controlling for them, we ensure that the relationship we find between the explanatory variables and the outcome is not spurious, but indicates a potential causal relationship.

5.3.1 Explanatory Variables

In order to effectively represent the implementation of the TRIPS agreement in our analysis, we use data from three specific explanatory variables: PIhigh, PIcon and yr20. The selection of these variables is based on their relevance and potential impact on the results of our study. Our analytical framework will explore different scenarios, ranging from models that integrate all these variables simultaneously to those where only a single variable is employed. A detailed presentation of these variables follows.

PIhigh

Our regression analyses incorporate a key treatment variable for the TRIPS agreement called PIhigh. It captures the evolution of the Park Index for each country over time and is constructed as a dummy variable. It is set to 1 the year a country in our dataset achieves a Park Index score of 2.5 or above, and 0 when the score is below. This allows us to identify when each country is being "treated", which is when it attains a significantly high Park Index score. We identify a Park Index score of 2.5 or above to indicate strong patent systems, and lower than 2.5 to be weak systems. This particular threshold has been adopted in several research articles, including one by Park and Wagh from 2002 (Park & Wagh, 2002).

The estimated coefficient of the PIhigh variable offers important insights. A positive coefficient in a scenario where the PI score exceeds 2.5 will suggest that strong patent protection typically leads to an increase in patent applications in a given country. Conversely, a negative coefficient imply the opposite.

Figure 2, displayed below, shows the significant Park Index escalation for developed and developing countries from 1980 to 2015. On the x-axis, one finds the time period under consideration. The evolution of the Park Index is tracked using the variable PIhigh, which is assigned a value of 1 if a country's PI score exceeds 2.5 and 0 otherwise. The two graphs represent the average PIhigh value for both developed and developing countries, which falls between 0 and 1 for all the years. The corresponding average PIhigh values can be identified on the y-axis.

The growth in the mean of PIhigh underscores the point of including the variable as an explanatory variable, particularly as it pertains to the impact of the TRIPS agreement on patent regimes. Historically, significant changes in patent regimes, particularly for developing countries and those with previously weak patent systems were relatively rare prior to 1995. However, the implementation of the TRIPS agreement directly resulted in the strengthening of intellectual property rights and patent protections across the globe (Park & Wagh, 2002). Thus, our inclusion of the PIhigh variable offers a critical perspective on these transformative shifts in patent law and policy.

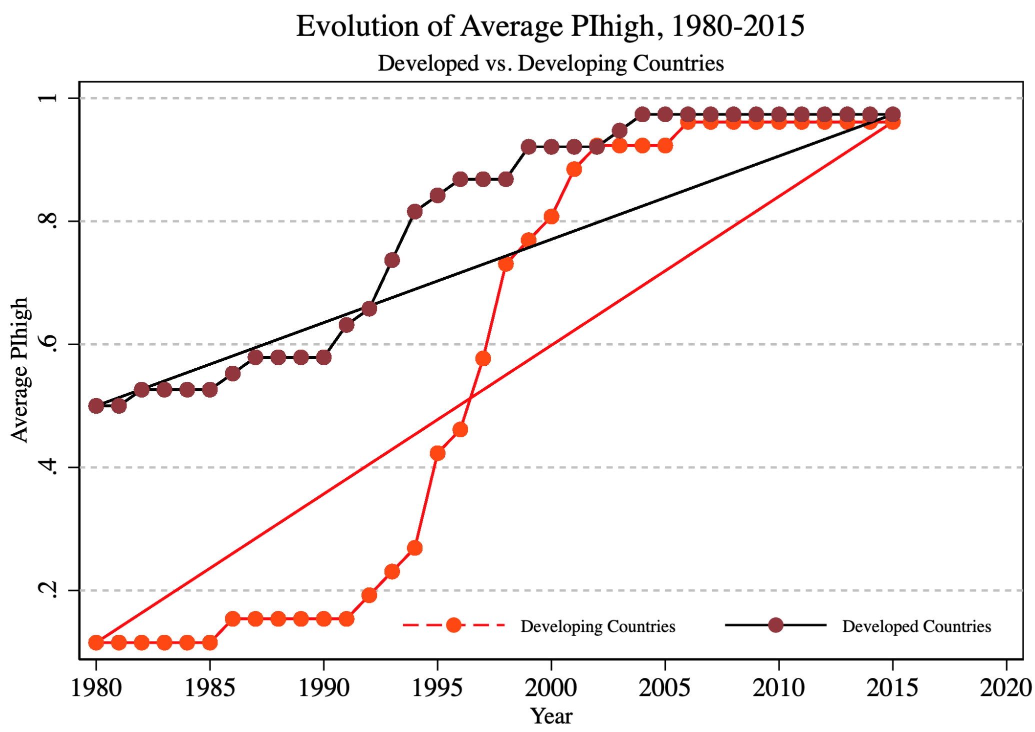


Figure 2: Average PIhigh

PIcon

PIcon is our second treatment variable. It is a time-variant variable that incorporates Park Index scores between 0 and 5 for all countries during the time horizon of the panel analysis. As the Park Index is updated every fifth year, prompting us to estimate values for the four years in-between based on the official index estimates. Most countries exhibit an overall increasing trend in the Park Index at varying rates. We fill in the gaps by evenly distributing the growth from the first to the fifth year across the intervening years. This method ensures a steady increase in the Park Index.

We believe that including the PIcon variable is crucial since it effectively represents the evolution of the Park Index values. Our goal here is to not only measure the impact of a strict patent regime (as indicated by PIhigh = 1), but also to identify the specific implications that each unit rise in the index may have on the outcomes of interest. This method provides an increased understanding of the relationship between patent protection evolution and its potential repercussions.

yr20

In evaluating the TRIPS agreement's impact, we deem it important to account for an explanatory variable reflecting a crucial feature of the agreement: the 20-year patent term rule, detailed in Article 33. According to this provision, a granted patent may last for up to 20 years from the date of the patent application's submission (WTO, n.d.-a). In our regression model, we include this feature with a binary variable named "yr20". This variable takes on either a 0 or 1 value, depending on when each country adopted the TRIPS agreement's 20-year patent term rule.

Our dataset extends from 1980 to 2021. Many nations, particularly developing ones, complied with TRIPS and its core aspects between 1995 and 2006, as demonstrated by the Park Index statistics. As such, the yr20 variable is set to 1 after each country implements the 20-year rule and 0 before it. For instance, since Costa Rica enacted the 20-year patent term in 2000, yr20 is set to 0 before 2000 and 1 thereafter.

The rationale behind defining yr20 in this way relates to the notable variation in the timing of TRIPS implementation and its features across countries. This is attributed to the WTO's decision to grant developing nations extended periods to adapt to TRIPS, as per Article 65 concerning transition periods. The objective was to facilitate a smoother transition, given that these countries initially possessed significantly fewer IPRs than their developed counterparts (WTO, n.d.-b).

According to TRIPS Articles 65.2 and 65.3, developing nations and those moving from central planning are not required to comply with all aspects of the agreement, including the patent duration restriction, until January 1, 2000. In addition, the least developed countries (LDCs) got until the 1st of January 2006, ref Article 66.1. On the 29th of June 2021, the WTO members agreed to delay this deadline for LDCs until 2034 (WTO, 2021). Consequently, the LDCs Madagascar and Bangladesh have still not complied with the TRIPS agreements rule of 20-year patent length (WTO, 2006).

It is worth noticing that not all countries in our study became WTO members before the signing of TRIPS. This leads to varied timelines for implementing the TRIPS agreement and its patent length rule, independent of their development status. According to Article 65, most countries that joined the WTO post-1995 agreed to implement the TRIPS agreement upon accession, subject to their specific membership terms (WTO, 2006). Given that the yr20 variable reflects an essential aspect of the agreement and somewhat indicates its implementation timeline, we deem it beneficial for our analysis.

After comprehensive research, we aim to compare yr20 with the Park Index's "duration" component, signifying the same rule's implementation year. Even though we can directly use the "duration" component from the Park Index as a variable, we want to ensure accuracy in our analysis by conducting our own investigations. For clarity in referencing, we further refer to the "duration" variable as "dur", as this is the variable name in our dataset and Stata codes.

In our comparative analysis between the yr20 and dur variables, we uncovered some inaccuracies in Park's dur variable. An example is Saudi Arabia (SA), which according to the dur variable adopted a 20-year patent length in 1960. However, after a thorough examination of the country's patent laws and correspondence with the European Patent Office (EPO) it became evident that the correct implementation year was 2004 - a great contrast to the year provided in the dur variable. A detailed overview of when all 68 countries implemented 20 years patent length can be found in Appendix 1.

With these findings, we continue acknowledging Park's significant work on the Park Index, and we decided it was essential to include the dur variable in our regression study. While the Park Index is generally well-accepted and seldom criticized, our own findings suggest discrepancies between his dur variable and our yr20 variable. With an intent to resolve these inconsistencies, we reached out to Park directly, seeking clarification on the sources used to determine the adoption year of the 20-year patent length rule for each country. In his answer dated May the 30th, 2023, he stated that due to the physical and dated nature of his research materials, he was unable to provide precise references. However, he did admit that his data may have come from secondary or tertiary sources. He also believed that the term of protection in Saudi Arabia may have been based on grants but then scored for applications by mistake.

Despite these discrepancies, our approach includes a comparison between the results derived from yr20 and dur variables, with an objective to find insightful outcomes. Our aim is to critically assess the role and implications of the dur variable in our regression analysis and discuss its relative accuracy and utility.

We also incorporate a lagged version of Park's duration variable, named "dur_lag". The modification is primarily due to that the estimation of Park's duration index component is being done every fifth year. This implies that the implementation of the 20-year patent length rule can be registered almost five years earlier than when it was registered.

On average, as the sample size grows large, each country implements the patent length rule approximately two and a half years before its registration date. This estimate emerges from the possibility of each country introducing the rule at any point within the five years leading up to its registration date. By lagging the dur variable by 2.5 years, we create the dur_lag variable, offering a more nuanced comparison with the yr20 variable.

When developing the yr20 variable, it is important to have in mind that there are numerous regional trade agreements, bearing relevance to the implementation of the TRIPS agreement. A notable agreement is the North American Free Trade Agreement (NAFTA), an economic trade accord between Canada, Mexico and the USA. It was signed in 1992 and came into force on January 1, 1994 (International Trade Administration, n.d.). NAFTA has significantly influenced the implementation of TRIPS in its member countries, as it already encompassed robust protections for IP. The agreement stipulated a minimum patent protection period of 20 years from the filing date (The Organization of American States, n.d.), aligning with the provision subsequently established by the TRIPS agreement.

Even before the TRIPS agreement, the USA had already adopted a 20-year patent length. Canada amended its legislation to meet both the NAFTA and TRIPS requirements for a 20-year patent protection period in 1989. As part of its preparations for NAFTA, Mexico executed reforms to its IPR law in 1991, extending the patent protection period to 20 years (Von Lewinski, n.d.). In summary, it is crucial to consider the influence of trade agreements like NAFTA, particularly in aspects such as the establishment of a 20-year patent length rule. This perspective provides a more nuanced understanding of why certain countries adopted regulations similar to those of TRIPS earlier than what was mandated by the TRIPS agreement itself.

5.3.2 Control Variables

We also include several control variables in our analysis. The reason is that elements beyond the TRIPS agreement may impact the amount of patent applications. The introduction of these control variables aims to standardize the trends across countries, thus simplifying the interpretation of effects derived from the coefficient estimates of the variables.

The selection of control variables include market size, wealth, investment levels, the extent to which an economy is open to trade, memberships in organizations that impose regulatory constraints on countries, and R&D expenditures. These control variables will be discussed in more detail in the subsequent sections.

Market Size

We suspect that the implementation of the TRIPS agreement have varying impacts on patent applications for countries with different market sizes. Therefore, we want to control for the countries' market size, typically denoted by the Gross Domestic Product. GDP signifies the aggregate value of goods and services produced within an economy, inclusive of product taxes and exclusive of subsidies not encompassed within the product's value. The numbers for GDP are in 2015 constant prices, given in US dollars (The World Bank, n.d.-a).

Furthermore, we suspect that countries with high GDP levels are more likely to generate more patent applications due to the greater resources for disposal. Moreover, larger corporations may face increased domestic and international competition in expansive markets, potentially incentivizing more patent applications irrespective of the extent of IPR protection. We use logged GDP in our analysis as a control variable.

Wealth

We also want to account for the wealth of each country. Therefore, our analysis includes a control variable for GDP per capita, also presented in logged values. GDP per capita, serving as our metric of wealth, is calculated as the total GDP divided by the population of each country. This measure ensures that we account for wealth on a per-citizen basis, which provides a more nuanced view of a country's economic status than total GDP alone.

To maintain consistency and comparability in our analysis, both GDP and GDP per capita are expressed in constant 2015 US dollars [3]. This ensures that the data for these two variables are adjusted for inflation and reflect real growth over time. Furthermore, presenting the data in a common currency allows for a fair comparison across countries, by controlling for exchange rate fluctuations.

Investments as % of GDP

It is also essential to control for drivers of economic growth, as this can affect the development of patent applications over time. With regards to this, we aim to use investments (Gross Fixed Capital Formation), a key determinant of domestic expenditure and real GDP growth. Specifically, we express it as percentage of GDP. This measurement effectively represents the ratio of investments to the total economic output, which provides valuable insights into a country's economic health (Stupnikova & Sukhadolets, 2019, p. 1). This includes investments in land improvements like drains and fences, machinery, equipment, and plants, as well as infrastructure like roads, schools, and hospitals (The World Bank, n.d.-b).

Although we have incorporated investments as a control variable, we anticipate a potential endogeneity issue, specifically simultaneity. This concern arises from our suspicion that a bidirectional causal relationship exists between investments and patent applications. While it is plausible that the level of investments may influence the number of patent applications, it is likely that the volume of patent applications impact the level of investments a country makes.

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[3] The most optimal approach would have been to use purchasing power parity (PPP) adjusted data for GDP. However, due to the unavailability of such data extending back sufficiently in time, we use GDP constant 2015 US $.

Openness

Further, we include a variable describing the degree of openness. Openness indicates to what extent a country engages in international trade relative to its GDP and is defined as follows:

$$\text{Openness} = \frac{\text{Export} + \text{Import}}{\text{GDP}} \times 100 \tag{2}$$

A country having a higher openness value means that a greater portion of its economic activity is linked to international trade. A high level of openness can be both positive and negative for a country. It can create opportunities for countries to enter new markets, increase their exports, and attract foreign investments, promoting economic growth and development (OECD, n.d.). However, increased openness also exposes countries to higher external risks, such as changes in global market conditions, currency risks and greater competition from foreign companies (Ferreira & Matos, 2020).

Overall, the openness variable is a helpful tool for assessing a country's level of integration in the global economy and can offer valuable insights into its economic performance. Export, import and GDP can be correlated with the other control and dependent variables, and are closely linked to our suspicion that more open economies are more attractive for non-residents to invest in and to apply for patents.

Furthermore, the openness variable holds significant relevance given the strong trade association of the TRIPS agreement. Hence, the inclusion of this variable in the context of the TRIPS agreement implementation presents an intriguing perspective.

Also, open economies can create opportunities for foreign firms to enter markets, increase their exports and imports, and attract foreign investments, promoting economic growth and development. Additionally, in general, working conditions are higher in companies that trade than those that do not, leading to higher prosperity and stability in conditions for doing business in such countries (OECD, n.d.).

The potential positive correlation between an open economy and technological progress motivates us to investigate the potential impact of economic openness on innovation in different countries, as indicated by Figure 3. For this reason, we question whether countries with a higher degree of openness attract a greater number of patent applications. This might also be attributed to foreign firms seeking protection in economically thriving countries that give cross-border growth opportunities and a stable environment for innovation protection.

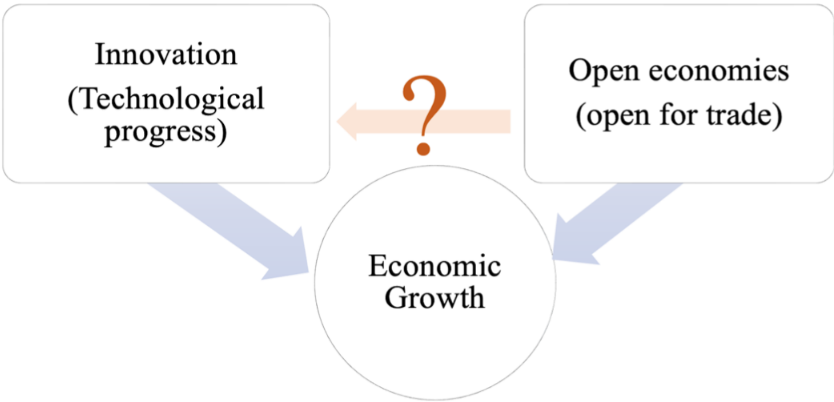

Figure 3: Potential effect of openness on innovation

Lastly, we want to point out that we have concerns regarding potential simultaneity issues. This arises from our suspicion that there is a mutually reinforcing causal relationship between an open economy and patent applications.

Memberships in EPO and the Signing of PCT

We recognize the need of considering global structural changes and significant events that might influence patent application trends. For instance, many countries in our dataset have seen changes due to the expansion of the European Patent Office's (EPO) membership. This may significantly affect IPR standards. To control for this, we introduce the dummy variable EPOyr, indicating each country's EPO membership status (EPO, n.d.). For example, for Norway that joined the EPO in 2008, EPOyr replicates 1 from 2008 and 0 before that.

Similarly, within this study's timeframe, 64 out of 68 countries in the dataset have signed the Patent Cooperation Treaty (PCT). This is an international treaty assisting inventors in securing global patent protection. We account for this by incorporating the PCTyr dummy variable, indicating the year of PCT ratification for each country.

Both EPOyr and PCTyr, as time-variant variables, mirror the evolving dynamics of each country's alignment with these organizations. Their inclusion provides a nuanced understanding of the influence exerted by countries' accession to the EPO and their ratification of the PCT.

R&D

The last control variable we choose to integrate into our regression analysis is Research and Development expenditures (named RD in the regressions). R&D expenditures are defined as the portion of a nation's Gross Domestic Product committed to R&D investments. This broad measure includes both capital and current expenditures across four main sectors: Business Enterprise, Higher Education, Government, and Private Non-Profit. The holistic view of R&D funding spans the entire spectrum of research, encompassing basic and applied research through to experimental development (The World Bank, n.d.-c).

The generally accepted relation between R&D expenditures and the degree of inventive output implies that when firms invest more in R&D, they are more likely to produce a higher number of novel technologies, processes and goods. This may elevate the number of patent applications (Cohen et al., 2002). As R&D investments are registered within a country's border, the data is residents' expenditures on R&D. Therefore, we believe that R&D expenditures are positively correlated with patent applications from residents in both developed and developing countries. The potential relationship is illustrated in Figure 4.

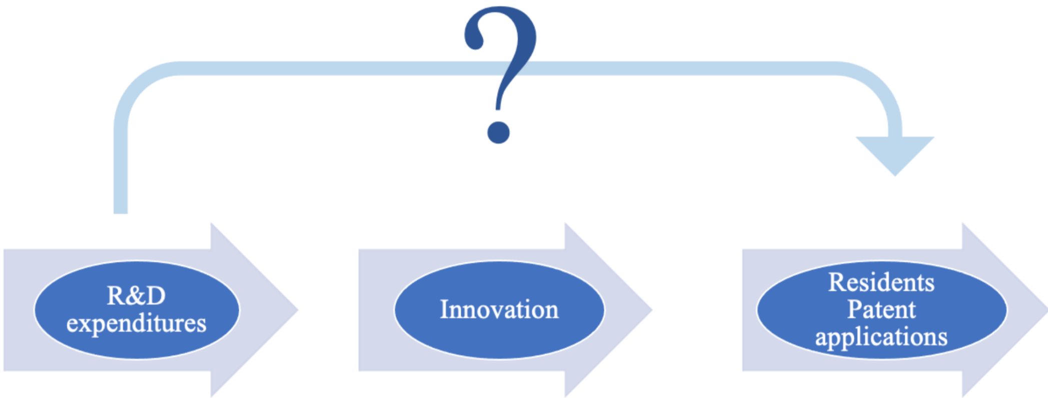

Figure 4: R&D expenditures' potential effect on resident patent applications

Investments in R&D can lead to patent-worthy inventions. Patents offer protection for these investments, paving the way for returns through licensing or a competitive advantage (Arundel & Kabla, 1998). Hence, we suspect that there is as a direct and positive link between R&D spending and resident patent applications. Therefore, it is crucial to control for R&D expenditures in our regression models.

Countries with high R&D expenditures may also draw more patent applications from non-residents. This might happen if overseas inventors perceive that countries spending substantially in R&D are more likely to make similar discoveries or locate information on their invention abroad and then potentially imitate it. Furthermore, in innovation and technology-rich regions, such as Silicon Valley, substantial investments are made in R&D. However, the pace of innovation in these areas might be so fast that many inventions is not being patented. This situation can present an opportunity for non-residents to take these unpatented innovations and secure patents for them in these high-tech areas. Conclusively, we also suspect that non-resident applications are positively affected by increased R&D expenditures.

5.4 Endogeneity Problem

Endogeneity is a common issue within the social sciences. Endogeneity implies that an explanatory variable is correlated with the error term, so the zero conditional mean assumption fails (Wooldridge, 2018, p. 82). In turn, it leads to the Ordinary Least Square estimate to be biased and inconsistent. Inconsistency means that when the size of the sample grows large, the distribution of the OLS estimator does not shrink and collapse to a spike that corresponds to the true value of the estimator - the opposite of consistency (Wooldridge, 2018, p. 83).

Endogeneity issues can arise due to various factors. These can include unobserved variables, measurement errors or simultaneity problems (also known as reverse causality) (Wooldridge, 2018, p. 534). For example, simultaneity can occur when the degree of wealth influences the number of patent applications simultanously as the number of patent applications also affects wealth, as illustrated in Figure 5. This situation presents a challenge for determining causal relationships, since only the explanatory variables should influence the dependent ones, not vice versa. Therefore, when conducting regression analysis, it is crucial to be aware of potential endogeneity issues.

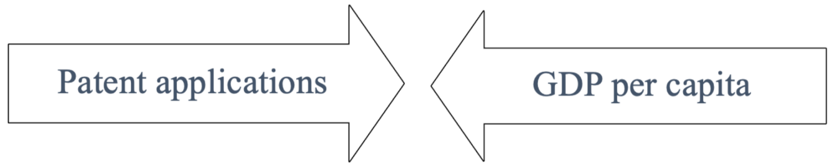

Figure 5: Potential simultaneity problem

5.5 Multicollinearity

Multicollinearity is the presence of a high degree of linear correlation between two or more independent variables in a regression model. As a result, multicollinearity can make determining the precise relationship between each independent variable and the dependent variable difficult (Siegel, 2016). The application of panel data can potentially introduce multicollinearity, which may present a challenge in our econometric model. It is therefore important to discuss and be aware of this.

The presence of multicollinearity in regression models can cause a variety of problems. These include difficulties in estimating the regression model's coefficients, as the standard errors may be inflated, and the coefficients may become unstable. Furthermore, multicollinearity can complicate the interpretation of regression model coefficients by making it difficult to identify the independent variable that influences the dependent variable. Furthermore, the regression model's predictive accuracy and precision may be reduced (Siegel, 2016).

Multicollinearity can impact the accuracy and reliability of regression analysis, but it depends on the purpose of the analysis and the degree of multicollinearity. Moderate levels of multicollinearity are generally not problematic, whereas strong multicollinearity, such as including the same variable twice, can cause numerical errors and significant problems. On the other hand, strong multicollinearity may not hinder the ability to produce reliable predictions if the primary goal of the analysis is to predict or forecast the dependent variable. However, if the goal is to interpret the individual effects of each independent variable on the dependent variable, multicollinearity may present significant difficulties as it becomes harder to isolate the effect of each independent variable (Siegel, 2016).

One approach to identify multicollinearity in a multivariate data set is to examine the correlation matrix, which displays the correlation coefficients between every pair of variables. If a pair of independent variables display a high correlation coefficient (close to 1 in absolute value) it indicates a strong association between them, suggesting that these variables measure similar aspects of the phenomenon under study (Siegel, 2016). As with any statistical measure, the correlation coefficient carries significance only when it is appropriately contextualized. The interpretation of this scaled value can often pose challenges.

A possible solution to remove discovered multicollinearity is to remove variables that duplicate information or include them in separate regressions. For example, if three different size measures are included as explanatory variables, it may be preferable to remove two of them or combine them into a single size measure, such as by averaging. This can help reduce information redundancy and improve the accuracy of the regression analysis (Siegel, 2016).

Several classification systems exist to interpret correlation coefficients in terms of absolute values. Coefficients under 0.35 generally indicate weak or low correlations, while values between 0.36 and 0.67 suggest moderate correlations. Strong or high correlations are represented by coefficients ranging from 0.68 to 1.0. Especially high correlations are signified by coefficients over 0.90. While these categories are not definitive rules, they are widely recognized and used in statistical analysis (Taylor, 1990). Therefore, we have chosen to use this classification scheme for our subsequent discussions and interpretations.

Table 5 replicates the correlation coefficients between the independent variables. Some of them are considered moderately correlated, such as PIhigh and yr20, PIhigh and dur, and between yr20 and the two dur variables. These correlations are also especially important to consider, as these variables are meant to be used to measure the effect of TRIPS on patent applications, the purpose of the analysis. The potential multicollinearity is most likely due to the fact that they are based on similar components, just replicated a little differently. As we suspect some multicollinearity due to moderate correlation between the above-mentioned variables, we compute separate regressions where only one of the multi-correlated variables appears.

Table 5: Correlation Matrix

	lappl	PIhigh	PIcon	yr20	dur	dur_lag	lGDP	lgdp_cap	openess	PCTyr	EPOyr	invest	RD
lappl	1.0000												
PIhigh	0.1625	1.0000											
PIcon	0.1339	0.1502	1.0000										
yr20	0.1816	0.6274	0.1073	1.0000									
dur	0.1700	0.5251	0.0471	0.7167	1.0000								
dur_lag	0.1845	0.5438	0.0714	0.7229	0.8708	1.0000							
lGDP	0.8774	0.1918	0.1132	0.2220	0.2053	0.2163	1.0000						
lgdp_cap	0.1346	0.4361	0.1407	0.3946	0.3512	0.3580	0.3035	1.0000					
openess	-0.1180	0.0060	-0.0616	-0.0398	-0.0566	-0.0754	-0.1734	0.0331	1.0000				
PCTyr	0.2468	0.3522	0.0838	0.1997	0.2152	0.2182	0.2844	0.2398	-0.3170	1.0000			
EPOyr	-0.2986	0.1929	0.1131	0.1843	0.1506	0.1420	0.0091	0.5622	-0.0717	0.2239	1.0000		
invest	0.2451	0.0902	0.0209	0.0296	0.0035	0.0216	0.1969	-0.0104	-0.1071	0.1347	-0.0971	1.0000	
RD	0.4428	0.2169	0.1233	0.2047	0.1935	0.1948	0.4563	0.6486	-0.1084	0.3422	0.2799	0.1294	1.0000

A moderate correlation exists between the variables GDP per capita and R&D. This can complicate the interpretation of their individual effects on the dependent variable (Siegel, 2016). However, in this context, our primary objective is to determine the influence of the implementation of the TRIPS agreement, rather than the effect of having a high per capita GDP or extensive resources dedicated to R&D. As a result, we do not consider multicollinearity to be a major concern for our control variables.

5.6 Regressions

We use seven different dependent variables creating seven regressions. These are logged values of total patent applications, of applications from residents and non-residents in both developed and developing countries, respectively. As mentioned earlier, not all four "TRIPS variables" will be incorporated in the regressions at the same time, due to potential multicollinearity. Therefore, these will also appear one by one. Below, the regression for overall patent applications is shown.

$$\begin{aligned}\ln(\text{Patent Applications}_{it}) = \beta_0 + \beta_1 \text{Treatment}_{it} + \beta_2 \ln(\text{GDP}_{it}) \\ + \beta_3 \ln(\text{GDP per capita}_{it}) + \beta_4 \text{Invest}_{it} \\ + \beta_5 \text{Openness}_{it} + \beta_6 \text{PCTyr}_{it} + \beta_7 \text{EPOyr}_{it} \\ + \beta_8 \text{RD}_{it} + \varepsilon_{it} \\ \text{where Treatment}_{it} = [\text{PIhigh}_{it}, \text{PIcon}_{it}, \text{yr20}_{it}] \qquad (3)\end{aligned}$$

We log-transform variables like patent applications, GDP, and GDP per capita for several reasons. Firstly, logarithms convert changes from units to percent, providing a proportional understanding of relationships. Secondly, it normalizes skewed variables, making them more suitable for statistical analysis and meeting model assumptions. Logarithmic transformation also improves the modeling of non-linear relationships and reduces the risk of overfitting by avoiding excessive complexity. Lastly, it rescales coefficients into a normal distribution, simplifying interpretation and facilitating meaningful comparisons between variables (University of Virginia, n.d.). The remaining variables are not log-transformed since they are either already provided as a proportion of GDP or are dummy variables.

5.6.1 Interaction Term as Robustness Check

In our regression analyses, we aim to include an interaction term for robustness checks. This help us understand if one variable's effect depend on another variable. By doing so, we can check if variable relationships stay consistent across different groups or conditions (Cohen et al., 2003).

To begin with, we start by conducting regressions without the inclusion of an interaction term. Further, we carefully observe and record the coefficients obtained from these regressions. Subsequently, an interaction term will be introduced into the model and the resulting outcomes will be compared to the original findings. The coefficient estimate for the interaction term represents the change in the effect of the first variable on the dependent variable for a one-unit increase in the second variable. In other words, it shows how the relationship between the first variable and the dependent variable changes depending on the level of the second variable. The coefficient of the interaction term itself represents how the slope of the effect of the first variable varies with each unit increase in the second (Cohen et al., 2003). Statistical significance in the interaction term coefficient suggests that the impact of one variable on the outcome variable is dependent on the level of another variable.

We aim to incorporate the interaction term "PIhigh*gdp_cap", formulated through the multiplication of the binary time-variant treatment variable PIhigh and the variable for gdp per capita. The product of these two will be included in the regression analysis, allowing us to estimate its corresponding coefficient. It should be noted that we only employ one of the treatment variables, PIhigh.

The rationale behind this computation is to scrutinize whether wealth, represented by GDP per capita, has an augmented effect on patent applications when a country is concurrently undergoing a change from low to high PI score. More explicitly, we aim to discern whether the influence of a country's increased wealth on the number of patent applications is either amplified or mitigated by the implementation of the TRIPS agreement. Specifically, we question whether countries with weak IPR protection prior to TRIPS and strong protection after, experience an enhanced impact on the number of patent applications when they also exhibit high GDP per capita values.

Including an interaction term between high patent protection and GDP per capita in a model can provide significant insights into the complex dynamics of patent applications. It allows us to better understand how the joint effect of these two variables influences patent applications, which will not be fully captured if they are only considered independently.

We suspect that the effect of high patent protection vary across countries with different levels of GDP per capita. This means that the coefficient for the interaction term will be above 0, indicating an interaction effect (Wooldridge, 2018, p. 192). For instance, in wealthier nations, robust patent protection may be more effective in encouraging innovation and subsequent patent applications because of the availability of resources to support R&D activities. However, in countries with lower GDP per capita, the effect of high patent protection may be more nuanced.

The most attentive reader may have already observed that the correlation coefficient between the two variables PIhigh and gdp_percap stands at 0.4361, indicating a moderate level of correlation. This further strengthens our reasoning for examining the effects of the interaction term between them.

The derivative of the interaction term is used to analyze the marginal effect of the interaction term in a regression model. To demonstrate this, we employ the following regression:

$$
\begin{aligned}
\ln(\text{Patent Applications}_{it}) = \beta_0 &+ \beta_1 \text{PIhigh}_{it} + \beta_2 \ln(\text{GDP}_{it}) \\
&+ \beta_3 \ln(\text{gdp\_cap}_{it}) + \beta_4 \text{Invest}_{it} \\
&+ \beta_5 \text{Openness}_{it} + \beta_6 \text{PCTyr}_{it} + \beta_7 \text{EPOyr}_{it} \\
&+ \beta_8 \text{RD}_{it} + \beta_9 \text{PIhigh}_{it} {*} \text{gdp\_cap}_{it} + \varepsilon_{it}
\end{aligned} \tag{4}
$$

To calculate the marginal effect of PIhigh on patent applications, compute the derivative of the logged value of patent applications in relation to PIhigh, as illustrated below:

$$
\frac{\partial \ln(\text{Patent Applications}_{it})}{\partial \text{PIhigh}_{it}} = \beta_1 + \beta_3 \cdot \ln(\text{gdp\_cap}_{it}) \tag{5}
$$

The interaction term between PIhigh and GDP per capita demonstrates that its impact on patent applications varies. This term captures the effect of strong patent protection for different GDP per capita levels. In essence, it permits PIhigh's influence to be dependent on GDP per capita. This dependency will be investigated further.

5.7 OLS and POLS

In the context of employing linear panel data models, the potential for correlated model errors poses several significant challenges. Firstly, autocorrelation (also called serial correlation) where model errors within a unit are correlated over time may raise a potential issue. This phenomenon infringes on the assumption that the error term is independently distributed across time, leading to estimators that may be both inefficient and biased (Baltagi, 2005, p. 84).

Furthermore, heteroscedasticity, where the variance of errors differs across time or across units presents another concern. While this does not introduce bias into the estimators, it compromises their efficiency, implying that they do not possess the minimum possible variance. Consequently, this can result in inaccurate standard errors, leading to incorrect inferences about the significance of the coefficients (Baltagi, 2005, p. 79). These concerns underscore the importance of careful model specification and the potential need for robust estimation techniques or corrections to standard errors in panel data analysis.

In microeconomic analysis, achieving independence among individual units is crucial. (Cameron et al., 2010, p. 236). However, a lack of independence can introduce biases and affect the reliability of our results. To address this issue, we adopt a clustering approach in our analysis. Specifically, we choose to cluster the data at the country level. By doing so, we ensure that each country is compared to itself before and after the implementation of TRIPS. Clustering at the country level helps to create independence for individual units within the analysis. This allows us to account for the potential correlation that may exist between observations within the same country, thereby mitigating any bias that may arise from the violation of the independence assumption.

When the errors are correlated, one has to control for correlation between errors for each unit to get valid results. We must do this since the standard OLS regression often underestimates the standard errors, which may affect the t- and F-statistics. This means that we may end up with statistically significant results from our regression without not necessarily being significant. If the error terms are uncorrelated with the explanatory variables one can use Pooled Ordinary Least Squares (POLS) to estimate panel data consistently (regress command). This is not always the case with panel data, since the error component frequently correlates with units over time (autocorrelation), which might lead to a correlation between the explanatory variables and error. Further, it often leads to too small standard errors and too big t- and F-statistics and biased estimates, causing heteroscedasticity (Mehmetoglu & Jakobsen, 2017, p. 231). When using POLS, the data is treated as if the observations are independent of the others (Mehmetoglu & Jakobsen, 2017, p. 233).

5.7.1 Autocorrelation

After conducting a regression analysis, it is essential to assess the model for autocorrelation. Autocorrelation violates the assumption of independently distributed errors over time, potentially leading to inefficient and biased estimates. The Durbin-Watson test is commonly employed to detect the presence of autocorrelation; however, it is not compatible with panel data. Instead, we utilized the serial correlation test developed by Drukker in 2003, implemented through the xtserial command (Mehmetoglu & Jakobsen, 2017, p. 233). A p-value less than our chosen significance level of 5 percent (0.05) enables us to reject the null hypothesis of no autocorrelation.

The p-values from the autocorrelation tests are shown in Table 6. The first column specifies which dependent variables is being used in the tests. It should be noted that the tests were carried out with only one explanatory variable, namely PIhigh. Upon implementing the autocorrelation tests, our models return p-values of less than 0.05 for all seven regressions except for resident applications in developing countries, indicating strong evidence of autocorrelation. A p-value of 0.05 or less signifies a robust autocorrelation issue within a model (Mehmetoglu & Jakobsen, 2017, p. 234). Consequently, the POLS approach is unsuitable for our analysis due to its inability to handle autocorrelation, which can induce homoscedasticity in the model's residuals.

Table 6: Results from Autocorrelation Tests

Dependent Variable	P-value
lappl	0.0000
lappl_developed	0.0003
lappl_developing	0.0010
lres_developed	0.0429
lres_developing	0.4430
lnonres_developed	0.0000
lnonres_developing	0.0062

To ensure the accuracy of our predictions and maintain the validity of our statistical inference, it becomes paramount to account for homoscedasticity within our regression models.

5.7.2 Heteroscedasticity

Furthermore, we examine the assumption of homoscedasticity, also known as the constant variance assumption. The concept of homoscedasticity stipulates that if the conditional variance of the residual, given the independent variable, remains consistent, the error term is homoscedastic. This is depicted in equation (6) where $\text{Var}(\epsilon_i)$ signifies the variance of the error term for the i-th observation, and σ^2 denotes constant variance across all observations.

$$\text{Var}(\epsilon_i) = \sigma^2 \tag{6}$$

Contrarily, if the variance of the residuals' conditional distribution fluctuates, the residuals are said to be heteroscedastic (Watson & Stock, 2019, p. 188). This can be statistically validated through the Breusch-Pagan/Cook-Weisberg test (1979 & 1983). If the p-value is below the significance level of 5 percent (0.05), the null hypothesis of constant variance across all levels of the independent variables is rejected, indicating heteroscedasticity in the errors (Mehmetoglu & Jakobsen, 2017, p. 234).

In our analysis, we find p-values below 0.05 in regressions for five dependent variables. A summary of these p-values is presented in Table 7. This means that heteroscedasticity seems to occur in at least five of the seven regressions. However, in the regressions for total applications in developing countries and for residents in developed countries, the p-values are considerably above the 0.05 threshold with respective p-values of 0.0706 and 0.8916. This implies that the dispersion of errors remains consistent across all values of the independent variables and that the variability of the errors within each individual is not contingent on the magnitude of the predicted values.

Table 7: Testing for Heteroscedasticity - Breusch-Pagan/Cook Wisberg Test

Variable	P-value
lappl	0.0000
lappl_developed	0.0000
lappl_developing	0.2176
lres_developed	0.0000
lres_developing	0.2673
lnonres_developed	0.0000
lnonres_developing	0.0000

Hteroscedasticity can lead to various issues that impact the validity and accuracy of the results. For instance, biased coefficient estimates can arise since the OLS estimator assumes that the errors' variance is constant. Inaccurate standard errors of the regression coefficients can also occur, leading to implications in testing the coefficients' significance. Moreover, heteroscedasticity can cause incorrect hypothesis testing because statistical tests assume that variance remains constant. Such incorrect testing can lead to wrong conclusions about the model or the significance of the variables. Lastly, heteroscedasticity can reduce the effectiveness of the prediction, resulting in less accuracy and increased variability in the model's predictions for certain observations. Detecting and addressing heteroscedasticity is essential to obtain reliable and accurate results before applying regression models (Watson & Stock, 2019, p. 190-191). To replicate homogenous results, we include several control variables for the OLS estimates to be as unbiased as possible.

5.7.3 Potential Solutions

OLS regressions suppose errors that are normally distributed and independent of other errors (no autocorrelation). One can relax these assumptions by applying robust standard errors. When having heteroskedasticity, it is more trustworthy to use robust standard errors. Utilizing the "vce(cluster ID)" command option generates independent observations across groups or clusters (ID represents each country), but it does not necessarily ensure independence within countries (fixed effects) (Mehmetoglu & Jakobsen, 2017, p. 234). For our panel data analysis, we cluster with the vce(cluster ID) command through all regressions, so that the standard errors become more accurate and to get lower t- and F-statistics. So, the standard error of i.e., the GDP variable is not calculated with the base in all observations but on the number of clusters.

Another problem with pooled OLS is that it does not distinguish between real and separate selection effects. This can result in spurious relationships from other variables affecting both the explanatory and dependent variables. One can try to solve this by including the variables affecting the independent and dependent variables or running fixed effects models by identifying within-unit variation (Mehmetoglu & Jakobsen, 2017, p. 236). Furthermore, we consider the use of fixed effects models and assess their performance compared to alternative random effects models.

5.8 Fixed effects vs. Random effect Models

A prevalent concern associated with panel data analysis is the potential correlation between the error term (e) and the explanatory variable (x). If such a correlation exists, it can result in biased coefficient estimates and thus skew the outcomes of the analysis. The selection of either a fixed or random effects model hinges on this correlation. Following the rule of thumb, if $\text{cov}(x_1, e_i) \neq 0$, one should use the fixed effects estimator. Conversely, if $\text{cov}(x_1, e_i) = 0$, then you should choose the random effects estimator (Mehmetoglu & Jakobsen, 2017, p. 240).

The Hausman test is a useful tool for comparing the fixed and random effects models. It compares these two models and suggest the one that best fits the data. A key metric in this process is the p-value generated by the Hausman test. If it is below the selected significance level (commonly 0.05), it implies a preference for the fixed effects model. This result signals that the null hypothesis, which posits no significant differences between the coefficients in the fixed and random effects models, should be rejected. The preference for the fixed effects model suggests the existence of specific individual effects in the data, which are correlated with the explanatory variables (Mehmetoglu & Jakobsen, 2017, p. 241).

Conversely, if the p-value exceeds the significance level, the random effects model is deemed a better fit. This suggests that the data either lacks significant individual-specific effects or thats such effects are uncorrelated with the explanatory variables (Mehmetoglu & Jakobsen, 2017, p. 241). By helping to determine the best model for the data at hand, the Hausman test plays a crucial role in data analysis.

Furthermore, using FE models removes the impact of factors that are country-specific and do not vary over time. However, these models also make it challenging to measure the effects of variables that vary only slightly over time (Amin & Qin, 2023). This issue seem pertinent to variables such as GDP, GDP per capita, and memberships in organizations like the EPO and PCT .

In this study, we implemented the Hausman test on regressions for total patent applications, for residents and non-residents for both developed and developing countries. Consequently, we create seven regressions in the regression analysis. The results from the Hausman tests are presented in Table 8. The tests for all models yield p-values below 0.05, indicating a statistically significant result given the threshold of 0.05. This indicates that we should choose to use the fixed effects models.

Table 8: Hausman Test with p-values for all regressions

Variable	P-value
All patents	0.0000
Developed	0.0000
Developing	0.0000
Residents in Developed	0.0005
Non-residents in Developed	0.0000
Residents in Developing	0.0171
Non-residents in Developing	0.0000

The coefficient estimates from the FE and RE models are quite different. These discrepancies indicate substantial systematic variations between the coefficients in the two models, refuting the assumption of omitted variables in the RE model. This provides support for the priority of the fixed effects model over the random effects model. The model comparisons is shown in Table 23, 24 and 25 in Appendix 3.

5.9 Description of Measures

Before delving into the presentation of our findings, it is critical to establish the importance of the statistical measures we deem to be the most important to discuss in order to assess the robustness of our conclusions. The metrics in focus are the R^2_{within} of the models, the intraclass correlation coefficient (rho), and the p-values associated with each regression coefficient. These provide insights into the models' explanatory power, the proportion of variation due to between-entity differences and the statistical significance of the individual variables, respectively.

5.9.1 R-squared and Within R-squared

The formula for the R^2_{within} is illustrated in equation (7) below. The term SSR_{within} represents the Sum of Squared Residuals. This is the sum of the squared variances between the observed and predicted values for each individual, after accounting for their average behavior over time. Essentially, this measures the unexplained variation within each unit, after having controlled for time-invariant individual characteristics (Wooldridge, 2018, p. 34).

Conversely, SST_{within}, or the within Total Sum of Squares, represents the total variance in the dependent variable after performing a "within" transformation. This transformation involves deducting each individual's mean value from their respective observations. The resultant values are then squared and summed. The SST_{within}, therefore, measures the total variation in the transformed dependent variable, representing both the explained and unexplained variations within each unit (Wooldridge, 2018, p. 34).

$$R^2_{\text{within}} = 1 - \frac{SSR_{\text{within}}}{SST_{\text{within}}} \tag{7}$$

5.9.2 Rho

When employing fixed effects models in panel data analysis, rho (ρ) symbolizes the intraclass correlation coefficient. This represents the fraction of the overall variation in the dependent variable attributed to variations within units over time. Equation (8) demonstrates how ρ is being computed. σ_u^2 signifies the variance that occurs between different entities, and σ_e^2 stands for the variance within a specific entity. This equation allows us to determine the fraction of overall variance attributable to the variation between entities (Mehmetoglu & Jakobsen, 2017, p. 247).

$$\rho = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_e^2} \tag{8}$$

5.9.3 P-value

In regression analyses, the p-value plays a crucial role in hypothesis testing, assisting in the determination of the results' statistical significance. The p-value, linked to each coefficient, provides an estimation of the likelihood that the coefficient differs from zero purely due to randomness, given that the null hypothesis holds true. Typically, in this situation, the null hypothesis asserts that a particular independent variable does not exert any influence on the dependent variable, meaning the real coefficient is zero. The p-value inversely corresponds to the strength of the evidence against the null hypothesis (Beers, 2023).

A p-value less than or equal to 0.05 supports the decision of evaluating the estimates to be statistically significant, leading to the rejection of the null hypothesis. This implies strong evidence supporting the significant relationship of the concerned independent variable with the dependent variable. Nonetheless, it is vital to understand that the p-value is just one component in the model. While it is important to consider statistical significance, it does not necessarily reflect the exact effect size or the practical importance of the result. The fact that a result appears statistically significant does not automatically mean that the model is a good fit or that it is appropriate for the data. When evaluating a regression model, other metrics and diagnostic tests should also be taken into account (Beers, 2023). In the analysis below, the p-value will be referred to as whether or not there is statistical significance among the results.

6 Results from the FE Models

The Fixed Effects model regressions yield several results, some of which seem to support our hypothesises, while others refute them. Our examination starts with an exploration of the implications of total patent applications. Following this, we will discuss the effects on both developed and developing nations, while also differentiating between residents and non-residents. The objective is to discern the varying impacts of the TRIPS agreement on these different patent application measures.

We use the categorizations proposed by the United Nations (UN) in 2014 for the classification of countries as either developed or developing (United Nations, 2014). This choice serves to structure our analysis. Appendix 2 gives an overview of these classifications.

6.1 Overall Estimates

Table 9 presents the coefficient estimates from the FE models across all seven regressions of patent applications, completed with robust standard errors. Within these regressions, we have employed the explanatory variable PIhigh to capture the effect of the TRIPS agreement.

The tabulated results are organized into eight distinct columns, each serving a specific role. The initial column contains the explanatory PIhigh and control variables. The second column, labeled ”All”, presents the estimated coefficients for all patent applications under consideration. The focus then shifts to developed and developing nations in the third and fourth columns, named ”Dev” and ”Dev.ing” respectively. The fifth and sixth columns, denoted as ”Res Dev” and ”Res Dev.ing”, portray applications from residents of developed and developing nations respectively. Finally, non-residents are accounted for in the seventh and eighth columns, labeled ”Non-Res Dev” and ”Non-Res Dev.ing”.

Table 9: Overview of all 7 regressions: Regression Results from FE models

	All	Dev	Dev.ing	Res Dev	Res Dev.ing	Non-Res Dev	Non-Res Dev.ing
	b/se	*b/se*	*b/se*	*b/se*	*b/se*	*b/se*	*b/se*
PIhigh	0.59***	1.29*	0.36**	0.05	−0.10	1.22	0.40**
	(0.21)	(0.75)	(0.14)	(0.41)	(0.21)	(0.75)	(0.18)
lGDP	0.08	−0.39	0.65	0.55	1.36	0.61	0.30
	(0.79)	(1.25)	(0.47)	(0.91)	(1.04)	(1.89)	(0.33)
lgdp_cap	0.74	1.47	0.20	0.56	0.06	−0.68	0.50
	(0.96)	(1.48)	(0.59)	(1.12)	(1.48)	(2.16)	(0.33)
openess	−0.00	−0.00	0.00	−0.00	−0.00**	−0.00	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
PCTyr	−0.45*	−0.78	−0.39***	−0.47	−0.23	−0.57	−0.30**
	(0.23)	(0.72)	(0.11)	(0.36)	(0.19)	(0.60)	(0.12)
EPOyr	−1.42***	−1.31***	0.11	−0.54**	1.60***	−2.19***	−1.85***
	(0.25)	(0.24)	(0.08)	(0.22)	(0.16)	(0.33)	(0.11)
invest	0.01	0.00	0.01**	0.00	−0.00	0.04*	0.01
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
RD	0.26*	0.36	0.17**	0.34	0.03	0.21	0.05
	(0.14)	(0.25)	(0.08)	(0.21)	(0.18)	(0.33)	(0.09)
_cons	−1.22	3.75	−11.08	−12.69	−29.59*	−2.68	−4.74
	(12.54)	(19.96)	(7.75)	(17.09)	(15.61)	(29.71)	(6.45)
Observations	1329	823	506	793	466	793	494
Within R-sq.	0.32	0.38	0.46	0.27	0.48	0.47	0.33
Rho	0.95	0.98	0.91	0.96	0.90	0.84	0.91

Note: Standard errors in parentheses

* Significant at 10% ($p < 0.10$)

** Significant at 5% ($p < 0.05$)

*** Significant at 1% ($p < 0.01$)

Further on, it is worth noting that only one explanatory variable will be included at a time later in the analysis, a point we further discuss in the forthcoming sections of this chapter.

6.2 Effect on Total Patent Applications

The result for for the total number of patent applications from the fixed effects model will be approached in five distinctive ways. This is done by changing the dependent variable when measuring resident and non-resident patent applications in developed and developing countries, each offering a unique perspective. The regression we use for total patent applications is as shown in equation (9) below.

$$
\begin{aligned}
\ln(\text{Patent Applications}_{it}) = {} & \beta_0 + \beta_1 \text{Treatment}_{it} + \beta_2 \ln(\text{GDP}_{it}) \\
& + \beta_3 \ln(\text{GDP per capita}_{it}) + \beta_4 \text{Invest}_{it} \\
& + \beta_5 \text{Openness}_{it} + \beta_6 \text{PCTyr}_{it} + \beta_7 \text{EPOyr}_{it} \\
& + \beta_8 \text{RD}_{it} + \varepsilon_{it} \\
\text{where Treatment}_{it} = {} & [\text{PIhigh}_{it}, \text{PIcon}_{it}, \text{yr20}_{it}] \qquad (9)
\end{aligned}
$$

In Table 10, the first column replicates the explanatory and control variables used. The second column reflects the coefficient estimates when all five "TRIPS" treatment variables (PIhigh, PIcon, yr20, dur and dur_lag) are incorporated into the regression (regression 1). The next four columns, present the coefficient estimates from the regressions when only a single "TRIPS" variable is included, thereby allowing for a more focused analysis. In the third column, PIhigh is the only explanatory variable, as indicated by the column heading "Only PIhigh" (regression 2). Subsequently, in the third column, yr20 is the only explanatory variable, signified by the heading "Only yr20" (regression 3). Following this, the fourth column, denoted as "Only PIcon", exclusively includes PIcon as the explanatory variable (regression 4). Lastly, the fifth and sixth column, labeled "Only dur" and "Only dur_lag", only includes the duration component in the Park Index, and the lagged version. Therefore, each column provides an unique analysis and understanding of the influence of individual "TRIPS" variables on the total number of patent applications.

From the first two regressions, the analysis reveals several significant relationships. We observe that total patent applications rise significantly when a score of 2.5 or above is attained ($PIhigh \geq 2.5$). This indicates that a high PI score corresponds to a substantial increase in patent applications. Also, a unit increase in the Park Index, for instance when PI elevates from 3 to 4 in score, appears to enhance patent applications a little on average. This is inferred from the coefficient estimates of PIcon. Moreover, the introduction of a country implementing the 20-year patent length rule (yr20=1) seem to correspond to a 65 percent rise in total applications. This is seen from the results in regression 3 as it demonstrate statistical significance. The coefficients from dur and dur_lag does seem to be inconclusive.

Table 10: Total Applications: Regression Results from FE models

	All TRIPS vars	Only PIhigh	Only PIcon	Only yr20	Only dur	Only dur_lag
	b/se	b/se	b/se	b/se	b/se	b/se
PIhigh	0.31*	0.59***				
	(0.18)	(0.21)				
PIcon	0.05***		0.06***			
	(0.02)		(0.02)			
yr20	0.40			0.65***		
	(0.26)			(0.23)		
dur	0.08				0.31	
	(0.23)				(0.21)	
dur_lag	0.02					0.32
	(0.16)					(0.20)
lGDP	0.07	0.08	0.43	−0.15	0.01	0.04
	(0.80)	(0.79)	(0.79)	(0.80)	(0.78)	(0.80)
lgdp_cap	0.82	0.74	0.56	0.97	0.80	0.78
	(0.94)	(0.96)	(0.94)	(0.96)	(0.95)	(0.96)
openess	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
PCTyr	−0.51**	−0.45*	−0.36	−0.38*	−0.34	−0.34
	(0.24)	(0.23)	(0.23)	(0.22)	(0.23)	(0.23)
EPOyr	−1.45***	−1.42***	−1.46***	−1.47***	−1.45***	−1.44***
	(0.23)	(0.25)	(0.25)	(0.24)	(0.26)	(0.26)
invest	0.01	0.01	0.01	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
RD	0.31**	0.26*	0.30**	0.27*	0.24*	0.25*
	(0.15)	(0.14)	(0.15)	(0.14)	(0.14)	(0.14)
_cons	−2.18	−1.22	−8.43	2.57	0.22	−0.35
	(12.78)	(12.54)	(12.59)	(12.65)	(12.51)	(12.74)
Observations	1284	1329	1284	1329	1329	1329
Within R-sq.	0.35	0.32	0.33	0.33	0.32	0.32
Rho	0.95	0.95	0.90	0.97	0.96	0.95

Note: Standard errors are in parentheses
* Significant at 10% (p < 0.10)
** Significant at 5% (p < 0.05)
*** Significant at 1% (p < 0.01)

The control variables yield several noteworthy observations from the regression results. The PCTyr variable exhibits quite an positive influence across several regressions. In the first regression, which incorporates all explanatory variables, PCTyr registers a substantial negative impact on total patent applications, as denoted by its coefficient -0.51. However, when considering a single explanatory variable, the effect of PCTyr seems less pronounced, but is still quite substantial. Yet, the coefficient estimates in regression 3, 5 and 6 fail to demonstrate statistical significance.

Furthermore, our analysis reveals that membership in the European Patent Office significantly decreases the total number of patent applications. This is supported by statistically significant results in all six regressions. Lastly, the results suggest that R&D expenditures exert a positive influence on patent applications despite what regression result one looks at.

The R^2_{within} values ranges from 0.32 to 0.35 across all regression analyses conducted. This relatively consistent range suggests that our models' performances are stable across different analyses. It shows that 32 to 35 percent of the variation observed in the dependent variable can be accounted for by the independent variables over time, when looking within each individual entity. This consistency in explanatory power is a promising indicator of the models' reliability.

The Rho value ranges between 0.90 and 0.97 across all regression models. This relatively consistent range suggests that our models are robust across various analyses. It indicates that 90 to 97 percent of the total variability in the dependent variable is due to changes within the individual units over time.

6.3 Developing Countries

The fixed effects model for developing countries is also structured through five distinct methods, in the same way as for the total amount of patent applications. This also extends to the subsequent sections, where the results from both resident and non-resident analyses will be presented. The regression we use for patent applications in developing countries is illustrated in equation (10).

$$\begin{aligned} \ln(\text{Patent Applications Developing}_{it}) = \beta_0 &+ \beta_1 \text{Treatment}_{it} + \beta_2 \ln(\text{GDP}_{it}) \\ &+ \beta_3 \ln(\text{GDP per capita}_{it}) + \beta_4 \text{Invest}_{it} \\ &+ \beta_5 \text{Openness}_{it} + \beta_6 \text{PCTyr}_{it} + \beta_7 \text{EPOyr}_{it} \\ &+ \beta_8 \text{RD}_{it} + \varepsilon_{it} \\ \text{where } \text{Treatment}_{it} &= [\text{PIhigh}_{it}, \text{PIcon}_{it}, \text{yr20}_{it}] \end{aligned} \tag{10}$$

Table 11 provides evidence that a Park Index above 2.5 in developing countries leads to a significant rise in patent applications. This effect is observed in the two first regressions and seem statistically significant. The PIcon variable also replicates positive coefficient estimates in the first and third regressions, but these estimates are less extreme.

When considering the implementation of the 20-year rule through the yr20 variable, we strive to find evidence of any effects due to no statistically significant estimates across all regressions. Additionally, none of the coefficient estimates for dur and dur_lag appear to have a substantial effect.

Overall, the findings suggest a positive effect of the TRIPS agreement's implementation on patent applications in developing countries. This effect is particularly supported by the results from the two Park index variables PIhigh and PIcon.

Table 11: FE Model Regression Results: Applications in Developing Countries

	All TRIPS vars	Only PIhigh	Only PIcon	Only yr20	Only dur	Only dur_lag	
	b/se	*b/se*	*b/se*	*b/se*	*b/se*	*b/se*	*b/se*
PIhigh	0.27**	0.36**					
	(0.10)	(0.14)					
PIcon	0.03**		0.04**				
	(0.01)		(0.02)				
yr20	0.16			0.21			
	(0.13)			(0.19)			
dur	0.02				0.02		
	(0.19)				(0.17)		
dur_lag	−0.23					−0.06	
	(0.21)					(0.13)	
lGDP	0.85*	0.65	0.91*	0.59	0.70	0.74	
	(0.46)	(0.47)	(0.53)	(0.48)	(0.48)	(0.47)	
lgdp_cap	0.11	0.20	0.09	0.26	0.19	0.17	
	(0.60)	(0.59)	(0.64)	(0.61)	(0.62)	(0.61)	
openess	0.00	0.00	0.00***	0.00	0.00	0.00**	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	
PCTyr	−0.42***	−0.39***	−0.36***	−0.32**	−0.30**	−0.30**	
	(0.10)	(0.11)	(0.11)	(0.12)	(0.11)	(0.12)	
EPOyr	−0.02	0.11	0.04	−0.09	0.07	0.11	
	(0.18)	(0.08)	(0.09)	(0.21)	(0.18)	(0.11)	
invest	0.01*	0.01**	0.01	0.01**	0.01*	0.01*	
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	
RD	0.17**	0.17**	0.16**	0.17**	0.16*	0.15*	
	(0.07)	(0.08)	(0.07)	(0.08)	(0.09)	(0.08)	
_cons	−15.45**	−11.08	−16.63*	−10.06	−12.15	−12.96*	
	(7.48)	(7.75)	(8.92)	(7.88)	(7.73)	(7.59)	
Observations	498	506	498	506	506	506	
Within R-sq.	0.49	0.46	0.46	0.45	0.44	0.44	
Rho	0.89	0.91	0.88	0.92	0.91	0.90	

Note: Standard errors in parentheses

* Significant at 10% ($p < 0.10$)

** Significant at 5% ($p < 0.05$)

*** Significant at 1% ($p < 0.01$)

Across all five regression analyses, a notable finding is that a large market size, measured by GDP, shows a strong and positive effect on patent applications in developing countries. However, this only seem to be apparent in regression 1 and 3. Another interesting observation is the consistently negative coefficients for the PCTyr variable through all regressions, ranging from -0.30 to -0.42. It is noteworthy that the coefficients for PCTyr are more extreme in the initial regression where multiple explanatory variables are included, compared to the regressions with only a single explanatory variable. Furthermore, it also seems like there are a positive effect of increased R&D expenditures. This finding is quite expected.

The within R^2_{within} values hovers around 0.45 across all regression analyses, indicating that approximately 45 percent of the variation in the dependent variables can be explained by the independent variables when considering the data within each individual entity over time. Similarly, the rho values consistently range between 0.88 and 0.92 across the regression models. This suggests that approximately 90 percent of the total variability in the dependent variables can be attributed to changes within the individual units over time.

6.3.1 Residents

Table 12 provides insights into the effect of TRIPS treatment variables on resident patent applications in developing countries. The results indicate that the coefficient estimates for the explanatory variables exhibit variability and lack statistical significance. This is evident from the low coefficient estimates and the absence of significant relationships. The only coefficient estimate that appears to be statistically significant is for the yr20 variable in the first and third regression. Overall, we are cautious with concluding with any strong effects.

Table 12: FE Model Regression Results: Resident Applications in Developing Countries

	All TRIPS vars	Only PIhigh	Only PIcon	Only yr20	Only dur	Only dur_lag
	b/se	b/se	b/se	b/se	b/se	b/se
PIhigh	−0.25	−0.10				
	(0.25)	(0.21)				
PIcon	−0.04		−0.02			
	(0.03)		(0.03)			
yr20	0.51***			0.45*		
	(0.16)			(0.23)		
dur	0.03				0.25	
	(0.18)				(0.24)	
dur_lag	0.07					0.29
	(0.17)					(0.24)
lGDP	1.06	1.36	1.41	1.11	1.27	1.22
	(1.02)	(1.04)	(1.08)	(0.99)	(1.01)	(1.01)
lgdp_cap	0.13	0.06	−0.07	0.18	0.02	0.08
	(1.41)	(1.48)	(1.51)	(1.38)	(1.42)	(1.41)
openess	−0.00**	−0.00**	−0.00***	−0.00***	−0.00**	−0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
PCTyr	−0.20	−0.23	−0.25	−0.29	−0.27	−0.28
	(0.17)	(0.19)	(0.18)	(0.19)	(0.19)	(0.19)
EPOyr	1.12***	1.60***	1.61***	1.22***	1.41***	1.51***
	(0.20)	(0.16)	(0.16)	(0.18)	(0.17)	(0.15)
invest	0.00	−0.00	−0.00	0.00	−0.00	0.00
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
RD	0.03	0.03	0.00	0.06	0.03	0.04
	(0.18)	(0.18)	(0.19)	(0.17)	(0.17)	(0.18)
_cons	−22.84	−29.59*	−29.91*	−24.65	−27.16*	−26.55*
	(15.98)	(15.61)	(16.22)	(15.37)	(15.63)	(15.48)
Observations	458	466	458	466	466	466
Within R-sq.	0.52	0.48	0.49	0.49	0.48	0.49
Rho	0.91	0.90	0.90	0.90	0.90	0.90

Note: Standard errors are in parentheses
* Significant at 10% ($p < 0.10$)
** Significant at 5% ($p < 0.05$)
*** Significant at 1% ($p < 0.01$)

Regarding the control variables, we only aim to find significant coefficient estimates for the EPO variable. Memberships in the EPO seem to positively affect resident applications. Notably, this occur even though Turkey is the only developing member nation in the EPO. This result calls for further investigation to better understand the relationship, as its practical significance is questionable.

In order to address potential bias, we conduct an additional FE model focusing specifically on resident patent applications in developing countries excluding the EPOyr variable, as shown in Table 13. We do this to mitigate any potential overestimation or spurious correlations that may arise from the inclusion of Turkey.

It is important to emphasize that statistical significance does not necessarily imply practical importance. A statistically significant association between variables may be confirmed through statistical tests, but the magnitude of the effect might not be substantial enough to have real-world impact (Frost, n.d.-b). By removing the EPOyr variable from the analysis, the coefficient for dur in regression five becomes statistically significant. However, we question drawing specific conclusions about the relationship between TRIPS and resident patent applications in developing countries, as the overall estimates remain relatively unchanged.

Table 13: FE Model Regression Results: Resident Applications in Developing Countries without the EPOyr variable

	All TRIPS vars	Only PIhigh	Only PIcon	Only yr20	Only dur	Only dur_lag
	b/se	*b/se*	*b/se*	*b/se*	*b/se*	*b/se*
PIhigh	−0.35	−0.13				
	(0.28)	(0.21)				
PIcon	−0.04		−0.02			
	(0.03)		(0.03)			
yr20	0.72***			0.67***		
	(0.20)			(0.24)		
dur	0.20				0.44*	
	(0.12)				(0.22)	
dur_lag	−0.09					0.39*
	(0.19)					(0.23)
lGDP	1.07	1.54	1.62	1.11	1.34	1.34
	(1.02)	(1.10)	(1.14)	(0.99)	(1.03)	(1.05)
lgdp_cap	0.11	−0.04	−0.18	0.17	−0.09	−0.00
	(1.41)	(1.53)	(1.56)	(1.38)	(1.42)	(1.45)
openess	−0.00***	−0.00**	−0.00***	−0.00***	−0.00***	−0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
PCTyr	−0.21	−0.29	−0.32	−0.34	−0.33	−0.35
	(0.17)	(0.21)	(0.22)	(0.22)	(0.21)	(0.22)
invest	0.00	−0.00	−0.00	0.00	0.00	0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
RD	0.04	0.03	0.01	0.08	0.03	0.05
	(0.18)	(0.20)	(0.20)	(0.18)	(0.18)	(0.18)
_cons	−22.82	−33.34*	−34.32*	−24.75	−28.37*	−28.96*
	(15.90)	(16.96)	(17.61)	(15.38)	(16.06)	(16.48)
Observations	458	466	458	466	466	466
r2	0.496	0.424	0.437	0.467	0.446	0.438
rho	0.906	0.890	0.899	0.896	0.898	0.891

Note: Standard errors are in parentheses

* Significant at 10% (p < 0.10)

** Significant at 5% (p < 0.05)

*** Significant at 1% (p < 0.01)

Furthermore, when EPOyr is removed from the analysis, the R^2_{within} values for all regressions decrease from approximately 49 to around 45 percent. This indicates that the explanatory variables account for less variation in the dependent variable within each unit. This is not surprising, as fewer variables often leads to lower R^2_{within} (Frost, n.d.-a). However, the rho value is quite unchanged. Conclusively, excluding EPO from the analysis does not significantly alter the overall results, but it suggests that the impact of EPO on patent applications may be less significant than previously believed.

6.3.2 Non-Residents

When evaluating patent applications from non-residents in developing countries, the coefficient estimates present a distinct contrast to those for residents. Notably, the influence of PIhigh and PIcon on non-resident applications demonstrates a clear, statistically significant and positive effect in the context of stronger patent regimes. This is shown in Table 14 below. Specifically, the coefficients for PIhigh is between 0.29 and 0.40 and for PIcon between 0.06 and 0.07, indicating a substantial impact aligning with our hypothesis. However, the results from yr20, dur, and dur_lag do not yield significant outcomes. Nevertheless, the significant and positive influence of PIhigh and PIcon on non-resident applications reinforces their importance in understanding the dynamics of patent filings in developing countries.

Table 14: FE Model Regression Results: Non-Resident Applications in Developing Countries

	All TRIPS vars	Only PIhigh	Only PIcon	Only yr20	Only dur	Only dur_lag
	b/se	b/se	b/se	b/se	b/se	b/se
PIhigh	0.29**	0.40**				
	(0.13)	(0.18)				
PIcon	0.05***		0.06***			
	(0.01)		(0.02)			
yr20	0.16			0.23		
	(0.15)			(0.22)		
dur	0.06				0.03	
	(0.21)				(0.20)	
dur_lag	−0.29					−0.08
	(0.25)					(0.16)
lGDP	0.57	0.30	0.61	0.23	0.35	0.40
	(0.34)	(0.33)	(0.40)	(0.37)	(0.34)	(0.34)
lgdp_cap	0.39	0.50	0.38	0.58	0.49	0.47
	(0.32)	(0.33)	(0.37)	(0.39)	(0.35)	(0.32)
openess	0.00*	0.00*	0.00***	0.00	0.00**	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
PCTyr	−0.34***	−0.30**	−0.28**	−0.21*	−0.20	−0.19
	(0.10)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)
EPOyr	−2.00***	−1.85***	−1.94***	−2.07***	−1.90***	−1.85***
	(0.22)	(0.11)	(0.12)	(0.24)	(0.21)	(0.10)
invest	0.00	0.01	0.00	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
RD	0.05	0.05	0.05	0.05	0.03	0.03
	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)	(0.09)
_cons	−10.56	−4.74	−11.47	−3.55	−5.75	−6.85
	(6.72)	(6.45)	(7.84)	(6.99)	(6.63)	(6.92)
Observations	486	494	486	494	494	494
Within R-sq.	0.36	0.33	0.34	0.32	0.31	0.31
Rho	0.87	0.91	0.86	0.92	0.91	0.90

Note: Standard errors are in parentheses

* Significant at 10% ($p < 0.10$)

** Significant at 5% ($p < 0.05$)

*** Significant at 1% ($p < 0.01$)

Regarding the control variables, the analysis reveals that entering the PCT and becoming a member in EPO significantly reduce non-resident applications. The negative effect of EPOyr seems more extreme than the one for signing the PCT.

The R^2_{within} values range from 0.31 to 0.36, suggesting that the variables included explain between 31 and 36 percent of the variation in the dependent variable within each unit. On the other hand, the rho values range from 0.87 to 0.92. These R^2_{within} measures are generally lower compared to the regression with resident applications. This indicates that the regression model explains less of the variation in the data, and that there is less change over time within the different countries.

6.4 Developed Countries

The fixed effects model for developed countries is structured in the same way as for the previous models for patent applications. The regression we use for patent for developed countries is illustrated in equation (11).

$$
\begin{aligned}
\ln(\text{Patent Applications Developed}_{it}) = \beta_0 + \beta_1 \text{Treatment}_{it} + \beta_2 \ln(\text{GDP}_{it}) \\
+ \beta_3 \ln(\text{GDP per capita}_{it}) + \beta_4 \text{Invest}_{it} \\
+ \beta_5 \text{Openness}_{it} + \beta_6 \text{PCTyr}_{it} + \beta_7 \text{EPOyr}_{it} \\
+ \beta_8 \text{RD}_{it} + \varepsilon_{it} \\
\text{where Treatment}_{it} = [\text{PIhigh}_{it}, \text{PIcon}_{it}, \text{yr20}_{it}] \qquad (11)
\end{aligned}
$$

When analyzing the development of patent applications in developed countries, several significant findings emerge, shown in Table 15 below. From regression 2, it seems that getting a high PI score increases patent applications in developed countries. In regressions 1 and 3, we observe evidence suggesting a positive and statistically significant impact of five and six percent associated with a one-unit increase in the Park Index. Moreover, the results from regression 4 reflect that implementing the 20-year patent length rule leads to a great increase. Additionally, we observe a positive coefficient for the dur_lag variable, which further supports the notion that the adoption of the 20-year patent length rule positively affects the number of applications in developed countries.

Overall, the results indicate that both augmenting the Park Index and implementing the 20-year patent length rule yield some positive effects on patent applications in developed countries.

Table 15: FE Model Regression Results: Applications in Developed Countries

	All TRIPS vars	Only PIhigh	Only PIcon	Only yr20	Only dur	Only dur_lag
	b/se	b/se	b/se	b/se	b/se	b/se
PIhigh	0.83	1.29*				
	(0.66)	(0.75)				
PIcon	0.05**		0.06***			
	(0.02)		(0.02)			
yr20	0.25			1.00**		
	(0.41)			(0.46)		
dur	0.07				0.36	
	(0.31)				(0.35)	
dur_lag	0.35***					0.54*
	(0.12)					(0.29)
lGDP	−0.26	−0.39	−0.04	−0.40	−0.31	−0.30
	(1.39)	(1.25)	(1.36)	(1.25)	(1.26)	(1.26)
lgdp_cap	1.39	1.47	1.26	1.50	1.44	1.42
	(1.55)	(1.48)	(1.53)	(1.48)	(1.49)	(1.48)
openess	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
PCTyr	−0.88	−0.78	−0.43	−0.75	−0.55	−0.52
	(0.77)	(0.72)	(0.66)	(0.71)	(0.70)	(0.66)
EPOyr	−1.30***	−1.31***	−1.35***	−1.32***	−1.32***	−1.32***
	(0.24)	(0.24)	(0.24)	(0.25)	(0.26)	(0.25)
invest	0.00	0.00	0.00	0.00	0.00	0.00
	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)
RD	0.42	0.36	0.44	0.36	0.33	0.33
	(0.27)	(0.25)	(0.28)	(0.25)	(0.25)	(0.25)
_cons	0.39	3.75	−2.99	3.89	2.71	2.28
	(22.54)	(19.96)	(21.89)	(19.79)	(20.09)	(20.04)
Observations	786	823	786	823	823	823
Within R-sq.	0.40	0.38	0.38	0.37	0.37	0.37
Rho	0.96	0.98	0.95	0.98	0.97	0.97

Note: Standard errors are in parentheses

* Significant at 10% ($p < 0.10$)

** Significant at 5% ($p < 0.05$)

*** Significant at 1% ($p < 0.01$)

Furthermore, we observe a clear and statistically significant negative effect of being a member of EPO. This suggests that membership in general has a detrimental impact on patent applications in developed countries.

The R^2_{within} values consistently lay around 0.37-0.40, indicating that the independent variables explain approximately 37-40 percent of the variation in the dependent variable within each unit. Furthermore, the interclass correlations range from 0.95 to 0.98, suggesting that a significant proportion of the observed variation can be attributed to changes that occur over time within countries.

6.4.1 Residents

When examining patent applications from residents in developed countries, drawing definitive conclusions about the impact of the TRIPS agreement becomes more challenging. Table 16 reflect that a unit increase in the Park Index leads to 7 percent rise in resident applications. The coefficients for yr20 and dur_lag in the first regression are statistically significant, but we question the practical significance. This is due to that all the explanatory variables are included at once there and that they have opposite signs. Further, we strive to find other reliable coefficient estimates. Conclusively, we are careful with concluding with a causal effect of the TRIPS implementation on resident applications in developed countries.

Table 16: FE Model Regression Results: Resident Applications in Developed Countries

	All TRIPS vars	Only PIhigh	Only PIcon	Only yr20	Only dur	Only dur_lag
	b/se	b/se	b/se	b/se	b/se	b/se
PIhigh	0.73	0.05				
	(0.46)	(0.41)				
PIcon	0.07***		0.07***			
	(0.02)		(0.02)			
yr20	−1.23***			−0.35		
	(0.37)			(0.34)		
dur	0.21				0.33	
	(0.37)				(0.47)	
dur_lag	0.44**					0.51
	(0.18)					(0.43)
lGDP	1.15	0.55	1.00	0.60	0.56	0.57
	(1.03)	(0.91)	(1.06)	(0.90)	(0.91)	(0.91)
lgdp_cap	0.09	0.56	0.22	0.53	0.54	0.54
	(1.06)	(1.12)	(1.09)	(1.12)	(1.13)	(1.13)
openess	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
PCTyr	−0.54	−0.47	−0.53	−0.33	−0.62	−0.59
	(0.37)	(0.36)	(0.36)	(0.33)	(0.48)	(0.41)
EPOyr	−0.53**	−0.54**	−0.54***	−0.55**	−0.54**	−0.53**
	(0.20)	(0.22)	(0.20)	(0.21)	(0.21)	(0.21)
invest	0.00	0.00	−0.00	0.00	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
RD	0.37*	0.34	0.44*	0.34	0.31	0.30
	(0.20)	(0.21)	(0.23)	(0.21)	(0.19)	(0.19)
_cons	−24.26	−12.69	−21.52	−13.52	−13.13	−13.38
	(20.11)	(17.09)	(20.55)	(16.79)	(17.10)	(17.03)
Observations	756	793	756	793	793	793
Within R-sq.	0.33	0.27	0.30	0.27	0.28	0.28
Rho	0.90	0.96	0.90	0.95	0.96	0.96

Note: Standard errors are in parentheses

* Significant at 10% (p < 0.10)

** Significant at 5% (p < 0.05)

*** Significant at 1% (p < 0.01)

Moreover, being a member of the EPO consistently displays a distinct and negative effect. Lastly, heightened R&D investments demonstrate a positive influence on patent applications in regression 1 and 3.

The R^2_{within} values range from 0.27 to 0.33, indicating that the explanatory variables in the models account for between 27 and 33 percent of the variation in the dependent variable within each unit. The interclass correlations exhibit values between 0.90 and 0.96. This implies that around 90 percent of the observed variation is attributable to changes occurring over time within individual countries. In simpler terms, it suggests that the error terms in a given time period display a strong correlation with the error term in the preceding period, indicating that the model errors are not independent and identically distributed (i.i.d.).

6.4.2 Non-Residents

Implementing the 20-year patent length rule seem to have a positive impact on non-resident patent applications in developed countries. This is indicated by the results in regressions 1 and 4 in Table 17. However, we do not find any statistically significant effects for the remaining explanatory variables across any of the regressions. Therefore, the only notable and positive effects from the explanatory variables coefficients observed for non-resident applications is associated with the implementation of the patent length rule.

It is worth noting that investments seem to have a small positive effect of four percent on non-resident applications. However, this result is only significant at a 10 percent significance level. So, we are sceptical to this result as we aim to focus on 5 percentage levels. Furthermore, the regression results do indicate that being a member of the European Patent Office has a significant negative effect on non-resident patent applications. The remaining control variables do not provide substantial evidence to draw conclusions about their effects.

Table 17: FE Model Regression Results: Non-resident Applications in Developed Countries

	All TRIPS vars	Only PIhigh	Only PIcon	Only yr20	Only dur	Only dur_lag
	b/se	b/se	b/se	b/se	b/se	b/se
PIhigh	0.59	1.22				
	(0.69)	(0.75)				
PIcon	0.02		0.02			
	(0.03)		(0.04)			
yr20	0.72*			1.10**		
	(0.38)			(0.52)		
dur	0.14				0.26	
	(0.18)				(0.30)	
dur_lag	−0.14					0.18
	(0.15)					(0.33)
lGDP	0.44	0.61	0.69	0.58	0.75	0.74
	(2.16)	(1.89)	(2.13)	(1.89)	(1.89)	(1.89)
lgdp_cap	−0.56	−0.68	−0.72	−0.63	−0.75	−0.75
	(2.34)	(2.16)	(2.32)	(2.17)	(2.16)	(2.16)
openess	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
PCTyr	−0.66	−0.57	−0.20	−0.59	−0.33	−0.25
	(0.67)	(0.60)	(0.62)	(0.58)	(0.60)	(0.61)
EPOyr	−2.19***	−2.19***	−2.23***	−2.20***	−2.23***	−2.23***
	(0.33)	(0.33)	(0.33)	(0.33)	(0.33)	(0.33)
invest	0.04*	0.04*	0.04*	0.04*	0.04*	0.04*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
RD	0.28	0.21	0.27	0.21	0.17	0.18
	(0.37)	(0.33)	(0.36)	(0.33)	(0.34)	(0.34)
_cons	0.22	−2.68	−3.78	−2.12	−4.80	−4.74
	(34.58)	(29.71)	(34.27)	(29.53)	(29.66)	(29.72)
Observations	756	793	756	793	793	793
Within R-sq.	0.47	0.47	0.47	0.47	0.47	0.46
Rho	0.83	0.84	0.80	0.83	0.81	0.81

Note: Standard errors are in parentheses

* Significant at 10% ($p < 0.10$)

** Significant at 5% ($p < 0.05$)

*** Significant at 1% ($p < 0.01$)

The R^2_{within} values consistently hover around 0.47 across all regressions, suggesting that the explanatory variables included account for approximately 47 percent of the variation in the dependent variable within each unit. Additionally, the interclass correlation coefficient ranges from 0.80 to 0.84.

6.5 Results from FE Models with Interaction Term

We introduce an interaction term in our FE regression models. The interaction term consists of multiplying PIhigh and GDP per capita, and is named PIhighXGDPcap. This interaction term allows us to delve deeper into the relationship between high patent protection and per capita GDP, analyzing the combined impact on patent applications. It is important to note that when including the interaction term, we solely use PIhigh as the explanatory variable in the regressions.

Examining the regression results presented in Table 18, the interaction term yields three interesting findings from its coefficient estimates. We observe a significant increase in total patent applications in developing countries and for non-residents in developed countries. However, it appears a negative coefficient in the regression for residents in developing countries. This finding is evident from the negative and statistically significant coefficient estimates for the interaction term in the third, fifth and sixth regressions.

Table 18: FE Model Regression Results for all regressions, with interaction term

	Tot	Dev	Dev.ing	Res Dev	Non-Res Dev	Res Dev.ing.	Non-Res Dev.ing.
PIhigh	0.69	14.82	−5.50**	−9.46	−8.38***	19.08**	−5.12*
	(3.35)	(9.18)	(2.11)	(10.70)	(2.69)	(7.14)	(2.77)
lGDP	0.08	0.08	0.58	0.21	1.26	1.24	0.23
	(0.77)	(1.22)	(0.45)	(0.93)	(1.04)	(1.82)	(0.32)
lgdp_cap	0.74	1.48	−0.01	0.56	−0.24	−0.67	0.31
	(0.97)	(1.48)	(0.54)	(1.12)	(1.48)	(2.16)	(0.27)
openess	−0.00	−0.00	0.00***	−0.00	−0.00	−0.00	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
PCTyr	−0.45*	−0.91	−0.41***	−0.38	−0.24	−0.74	−0.32***
	(0.23)	(0.72)	(0.10)	(0.49)	(0.19)	(0.56)	(0.11)
EPOyr	−1.42***	−1.29***	0.10	−0.56**	1.58***	−2.17***	−1.86***
	(0.25)	(0.24)	(0.07)	(0.22)	(0.16)	(0.32)	(0.10)
invest	0.01	0.00	0.01**	−0.00	−0.00	0.04*	0.01
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
RD	0.26*	0.38	0.15**	0.33	0.01	0.23	0.03
	(0.14)	(0.25)	(0.07)	(0.21)	(0.18)	(0.33)	(0.09)
PIhighXlGDP	−0.00	−0.54	0.23***	0.38	0.32***	−0.72**	0.21*
	(0.13)	(0.35)	(0.08)	(0.42)	(0.10)	(0.27)	(0.11)
_cons	−1.31	−8.13	−7.62	−4.37	−24.66	−18.28	−1.46
	(12.02)	(18.82)	(7.69)	(16.81)	(15.77)	(27.54)	(6.57)
Observations	1329	823	506	793	466	793	494
Within R-sq.	0.32	0.38	0.48	0.27	0.49	0.47	0.34
Rho	0.95	0.97	0.91	0.96	0.91	0.86	0.91

Note: Standard errors are in parentheses.

Abbreviations: all. = all applications, dev. = developed, dev.ing. = developing, Res = resident, Non-Res = Non-resident.

* Significant at 10% ($p < 0.10$)

** Significant at 5% ($p < 0.05$)

*** Significant at 1% ($p < 0.01$)

7 Qualitative Method: Interview

We have conducted one in-depth interview with Gunnar Holen, the Chief Executive Officer (CEO) and founder of Nordic Electrofuel. In this way, we get a practical view of the subjects relevant to our thesis based on experiences and other knowledge. We start by presenting the interview object, his company and discuss why qualitative interviews are relevant to incorporate in our study. Lastly, the interview design will be presented. In appendix 5, one can also find a discussion on ethical and legal responsibilities we adhere to when doing the research and data collection.

7.1 Gunnar Holen, the CEO of Nordic Electrofuel

Gunnar Holen is a corporate and investment finance professional who has worked for 31 years within investment banking. In addition, he has a comprehensive background with experience in fundraising, mergers & acquisition activity, and has been a leader and participant in many placements. Further, he is an entrepreneur due to developing and founding CAR ASA, an investment bank, starting with two employees and 0 NOK in 2003, growing to 55 employees and 80 million NOK in revenue in 2007. Holen has a Master of Science in Business with a major in accounting and finance from BI Norwegian Business School, conducted in 1981 to 1985 (Holen, 2022).

7.2 Nordic Electrofuel

Nordic Electrofuel produces sustainable fuel (e-fuel) from hydrogen and CO^2 with the use of a Power-to-Liquid (PtL)-pathway. This includes electrolysis that uses renewable energy that splits water into oxygen and hydrogen. The process combines the hydrogen with CO^2 in a syngas reactor to produce the syngas, which is the technology and process patented (Nordic Electrofuel, n.d.). The e-fuel is directly filled into the tank, instead of charging an electric vehicle. This is fully compatible with the engines used today, thus resulting in a swift impact on reducing the carbon dioxide footprint.

7.3 Why use Qualitative Interviews?

Qualitative interviews are one of the most used ways of collecting data. It is a flexible method that can be applied almost everywhere and makes it possible to gain detailed and comprehensive descriptions of the topic under study (Tufte et al., 2016, p. 143). Hence, the interview conversation gives insight into a person's experiences through stories and explanations. Interviews are suitable when researchers need to allow the informant to express themselves more than in a traditional questionnaire (Tufte et al., 2016, p. 143). It is therefore relevant to implement an interview with an innovator like Holen. When doing so, we nuance our analysis and findings from the quantitative approach, with practical experiences giving insight into how his company is being affected by structural limitations caused by IPRs.

We choose to use a semi-structured interview. In this way, we are able to ask open questions and get the most out of the interview object's answers. This gives a greater balance between standardization and flexibility. Semi-structured interviews have an overall interview guide as a starting point, but the questions, topic, and order will vary. In a semi-structured interview, topic, questions and order are planned in advance. It can look like questions in a questionnaire, but the difference is that the questions in this type of interviews are more open and do not contain answer options in advance. Conducting the interview in this way, the researchers has a lower possibility to influence the answers of the interview objects. The answers also show how the interview objects have interpreted the questions. Even though one uses open questions, it might be wise to have some kind of standardization so the questions do not vary that much (Tufte et al., 2016, p. 147).

7.4 The Interview Design

During the interview, we choose to create and follow an interview guide. This is a overview of themes and general questions being addressed, related to the research question analyzed from the start until the end of the interview. The interview guide also contains sub-questions that assure the researchers that all aspects with relevance are being answered (Tufte et al., 2016, p. 147). Appendix 4 contains the complete interview guide for our interview with Holen in Norwegian, reflecting the language in which the interview was conducted.

8 Results from Interview with G. Holen

This section presents the findings from the in-depth interview conducted on the 24th of January 2023 with Gunnar Holen, CEO of Nordic Electrofuel, focusing on the topics of patents and the TRIPS Agreement. Holen, a leading figure in electro-fuel innovation, provided valuable insights on these topics.

Our aim was to gain an understanding of the role and impact of patents in the context of the TRIPS Agreement. We focused on the challenges and opportunities Nordic Electrofuel encounters in the patent landscape. This interview also served to explore Holen's perspective on effective patent strategies. The subsequent paragraphs present a summary of the interview, highlighting Holen's viewpoints on these critical matters.

8.1 Goals for the Future

Gunnar Holen and his company have ambitious goals for the future. They strive to become one of the world's leading e-fuel producers with a target production capacity of 1 billion liters (800,000 metric tons). They have established partnerships with stakeholders across Norway, Denmark and Iceland and received inquiries from Sweden. Renewable power as their key resource is crucial, and they prioritize access to renewable energy. Norway's advantage lies in its reliable hydroelectric power, providing a consistent energy source compared to solar and wind power, which are weather-dependent. To ensure an uninterrupted power supply, significant investments are required. Additionally, they have a subsidiary dedicated to developing a wind power portfolio known as Nordic Wind.

Their vision includes strong future growth. By 2050, their ambition is to produce 60 billion liters, satisfying approximately 12 to 13 percent of the global aviation industry's demand. As pioneers in this technology, they are observing emerging regulations mandating the use of e-fuel in the European Union, particularly in the aviation sector, where official mandatory blending targets are being introduced. These regulations also extend to other modes of transportation. The EU has set the target that 5.7 percent of all transportation should be powered by e-fuel by 2030.

8.2 Experience with Patents and Intellectual Property Rights

When we asked about Holen's and the company's experiences with patent implementation, he mentioned that the patent for the "Pox-rwgs" reactor took approximately two years to be granted, making Nordic Electrofuel the sole holder of this patent worldwide. They consider this timeframe quite long but have accepted it as part of the process. On the other hand, they appreciate the fact that it takes time because it allows other companies to raise objections if they believe parts of the patent application already exist, among other reasons. However, Holen emphasizes that it would have been more practical if the granting process had been shorter.

Further, we asked about Holen's stance on whether patents are expensive or not. He responded firmly, "Yes! It's terribly expensive!". Consequently, there is a dilemma regarding how many markets one should patent in. He further explains that they want to maintain the patents for 20 years. They have chosen to patent in the areas they consider most important to them, which include the UK, Europe, the USA, and Japan. Furthermore, they will consider whether to patent in other countries as well, but this is an economic question. Potential alternative countries and regions include for example China and the Middle East. The decision will be based on evaluating the financial feasibility. They aim to cover the markets they consider most important. In this regard, he thinks it is beneficial in Europe to have a single patent that applies to the entire region through the European Patent Office. This allows for streamlined protection and coverage across multiple European countries.

Next, we asked Holen about his perspective on the following statement: "Inventions patented in most countries and with the longest patent durations are the most valuable patents.". He agreed with this statement but did not provide further explanation for his reasoning.

Our conversation with Holen touched upon how Nordic Electrofuel assess the value of patents. According to Holen, one of the key challenges lies in the effective communicating of the worth of a patent to investors, particularly during its early usage stages. However, within the company, there is a clear understanding of how to predict patent value. They do this by estimating potential licensing opportunities through market assessments, analyzing market shares and pricing, among other factors. However, these predictions come with their own set of uncertainties. Despite this, it is clear that the company has put significant thought into sales projections, utilizing spreadsheets for organized and detailed forecasting.

Furthermore, we asked about the advantages and disadvantages of patenting compared to other alternatives. He highlighted concerns regarding the disclosure of their innovation when obtaining a patent and the potential for others to exploit the public transparency of the product. Initially, he emphasized that it is indeed an important topic and states that it is undoubtedly a dilemma. Some choose not to patent their innovations because once you obtain a patent your actions become public. This allows other actors to see what you have done and attempt to maneuver around it and use your work, even though they cannot replicate it exactly. However, if you have a patent and others misuse it, you have protection in the sense that you can file a lawsuit against them. Therefore, there is a delicate balance between patenting and keeping the innovation secret. In the development of the patent, they worked closely with the Norwegian University of Science and Technology (NTNU) and relied heavily on consultants.

Regarding patenting their technologies, Holen points out that they consider licensing out the patented process. They recognize that it can be an interesting revenue stream and a promising opportunity with high-income potential and low costs, making it a capital-efficient venture. Also, they aim to license out the technology because they have limited capacity to build the facility themselves. This is actually a relevant aspect of their business plan for the future and applies to both the Pox-rwgs reactor and the method once it becomes granted.

We also inquired about whether they have considered protecting their innovations through trade secrets instead of patenting. In response, he highlighted the risks associated with information leakage when relying on secrecy. Additionally, it was pointed out that if there is an opportunity to patent and take legal action against other actors, patenting is likely advantageous. However, for smaller companies with limited resources compared to larger ones, it becomes a matter of balancing the options available.

Further, we explored Holen's view on the role of IPRs in fostering creativity innovation. Holen expressed a firm belief in the stimulatory effect of IPRs on innovation. He underscored the strategic importance of IPRs, outlining their potential for licensing products or leveraging them to gain a competitive advantage.

Holen further highlighted that their experience over time has shown clear evidence of the financial rewards patents can bring. They have observed companies accruing significant profits due to patent protection. However, such profit tends to decline sharply once patent protection expires.

IPRs create temporary monopolies as patents grant exclusive rights to their owners. This leads to a deadweight loss in the economy. In this context, we asked Holen the following question: Do you believe that the benefits of patents outweigh the deadweight loss in the economy? Holen's response favors patents. He argues that without patents as intellectual property rights, no one would work on innovation, resulting in a significant loss of value creation and the incentive for creativity, as everyone would simply copy each other. This would lead to an economy resembling the Soviet Union before its dissolution, with overall lower prosperity. Therefore, it is crucial to allow inventors to enjoy the benefits of their innovations through patents; otherwise, societal value creation would be significantly reduced.

9 Discussion

In this chapter, we delve into a discussion of the regression results derived from the Fixed Effects models. These findings will be linked to insights gathered from the interview with Holen. By doing this, we facilitate a comprehensive and integrative understanding of the research question, creating a more nuanced analysis. Moreover, we compile these findings with existing theory and literature, thus positioning our study within the broader academic discourse.

9.1 Discussion of the Explanatory Variables

Table 19 provides an overview of the effects of the different explanatory variables on the dependent variables across seven distinct regression analyses. Each dependent variable corresponds to a specific column, leading to seven unique scenarios. The first column lists the explanatory variables used throughout the fixed effects regression analysis. The second column indicates the influence of these variables on all patent applications. The third column shows the total applications in developing countries (Tot), while the fourth and fifth columns represent applications from residents (Res.) and non-residents (Non-Res.) in these countries, respectively. The final three columns display the effects on total applications in developed countries, again divided into resident and non-resident submissions. The arrows shown in each cell provide an indication of the direction in which each explanatory variable influences the corresponding dependent variable.

As an example, consider the cell in the second row and second column. The upward arrow in this cell suggests that a high PI score (denoted as PIhigh=1) appears to positively impact the total number of patent applications, as inferred from our FE regression results.

Based on the regression analysis, it appears that among the five explanatory variables, PIhigh and PIcon exhibit the most significant effects. Even though PIcon replicate more statistical significant results, PIhigh seems to have a more pronounced impact in general on the various dependent variables. This is indicated by its higher and statistically significant coefficient estimates. The outcome aligns with our expectations, as PIhigh specifically measures the transition from weak to strong patent protection, making it suitable for capturing the TRIPS effect.

Table 19: Effects of Explanatory Variables on Patent Application Measures

Variable	All	Developing			Developed		
		Tot	Res.	Non-Res.	Tot	Res.	Non-Res.
PIhigh	↑	↑	-	↑	↑	-	-
PIcon	↑	↑	-	↑	↑	↑	-
yr20	↑	-	↑	-	↑	-	↑
dur	-	-	-	-	-	-	-
dur_lag	-	-	-	-	↑	-	-

All = All applications, Tot = Total applications in developing/developed countries, Res. = Residents, Non-Res. = Non-residents.

Note: The symbols ↑, ↓, and - represent positive effect, negative effect, and no effect respectively.

Interestingly, a unit increase in the Park Index seems to positively influence all kinds of patent applications, with one exceptions: applications from residents in developing countries. In this case, establishing any causal relationship becomes a challenging task. The positive impacts we observe are in line with the results derived from the coefficient for PIhigh. Yet, for PIhigh it is noteworthy that we also find it challenging to discern a relationship for patent applications in developed countries from residents and non-residents.

Our analysis reveals positive influences on non-resident applications in developing countries due to a unit increase in the Park Index and achieving a high PI score. This is illustrated through their upward pointing arrows. The finding aligns with our initial hypothesis, making it an anticipated result.

Moreover, valuable insight from our interview with Holen, the CEO of Nordic Electrofuel on January 24, 2023 becomes apparent. He emphasized that patenting an innovation in a particular country exposes it to potential exploitation, thereby deterring foreigners from filing patents in regions where such issues are widespread. Therefore, the implementation of more strict patent regimes can equip innovators with legal tools to combat those who infringe upon their intellectual property rights, thereby ensuring protection. In light of Holen's argument, it can be inferred that stringent patent regimes, characterized by a high PI, contribute to an upswing in non-resident patent applications in developing countries.

We strive to discern a relationship between elevated Patent Index scores on resident patent applications within developing nations. This trend can potentially be attributed to the low costs associated with imitation. Mansfield et al. (1981) indicate that businesses may imitate an innovation at a significantly lower cost than the original innovator invested in its development. This may deter the initial innovator from pursuing an innovation. Seen in the context of the North-South model, where the "South" (developing nations) tends to imitate the "North" (developed nations), residents in developing countries might be more inclined to replicate existing technological innovations rather than pursue and patent new ones. For this reason, resident patent applications might not change much due to TRIPS implementation.

The aggregate amount of patent applications directed towards developing countries appears to be experiencing a substantial increase, reflected through the PIhigh and PIcon coefficients. This trend is presumed to be primarily driven by a surge in non-resident applications, while the volume from resident applications seems to remain relatively stable.

Upon assessing the coefficient estimates for resident applications in developed countries, a positive and significant effect manifests as a result of a unit increase in the Park Index. However, this impact seems relatively low, standing at merely seven percent. Simultaneously, the other explanatory variables yield no considerable indications of a positive effect. This observed outcome may be due to the fact that many developed countries had implemented laws and regulations similar to the TRIPS agreement before its official introduction. Higher Park Index scores at an earlier stage are likely due to this reason.

For additional context, Table 20 below provides PI statistics from 1960 to 2015. The second and fifth columns present the average Park Index scores, the third and sixth columns represent the median, and the fourth and seventh columns reflect the growth in the median index for both developing and developed countries. It is important to note that the average values includes all outliers, extreme values that can distort the overall picture. As such, we rely more on the median value that disregards these outliers and provides a more accurate representation.

Interestingly, we find that the median PI score for developed countries was already high (above 2.5) before 1980. This early high score was not mirrored in developing countries until two decades later, around the year 2000. This means that by 1980, developed nations had already reached high scores, a milestone that developing countries did not achieve until 20 years later. So, developed countries have had a history of strong patent protection, positioning them more like a control group being less affected by the implementation of the TRIPS agreement. For this reason, it seems like the TRIPS agreement does not influence the number of resident applications to developed countries a lot.

It is intriguing to note that substantial growth in the median Park Index in developing countries occurred primarily around the years 1995 (73%), 2000 (29%), and 2005 (13%). This pattern suggests that these nations began to enhance their patent protection systems during this period. In contrast, developed countries witnessed their first significant surge in the median PI in 1980 (21%), followed by another noteworthy increase in 1995 (26%). The second rise is believed to be associated with the implementation of the TRIPS agreement, and the first in relation to several countries signing the EPC. This data suggests a distinctive pattern: Developed countries have spread their growth in patent protection strength over a wider time frame while developing countries experienced most of their growth immediately after the implementation of the TRIPS agreement.

Table 20: Park Index Average, Median and Growth in Median for Developing and Developed Countries

Year	**Developing**			**Developed**		
	Av.	**Med.**	**△ in Med.**	**Av.**	**Med.**	**△ in Med.**
1960	1.26	1.23		2.12	2.24	
1965	1.28	1.23	0%	2.32	2.38	6%
1970	1.39	1.29	5%	2.44	2.44	3%
1975	1.38	1.29	0%	2.45	2.48	1%
1980	1.43	1.30	1%	2.90	2.98	21%
1985	1.46	1.33	2%	3.00	3.23	8%
1990	1.51	1.33	0%	2.98	3.28	2%
1995	2.16	2.31	73%	3.86	4.14	26%
2000	2.96	2.98	29%	4.14	4.33	5%
2005	3.30	3.38	13%	4.31	4.33	0%
2010	3.43	3.43	1%	4.31	4.33	0%
2015	3.68	3.75	9%	4.30	4.42	2%

Note: Av. = Average, Med. = Median, △= Change/growth.

Following the initial analysis, it emerges that non-resident applications in developed countries appear to exhibit a positive response upon attaining a high score. This influence appears to be quite considerable; however it does only seem to be triggered by having implemented the 20-year patent length rule. The observation may suggest that increased patent protection in isolation may have limited impact. In addition, the implementation of 20-year patent length seems to exert a substantial impact on the overall quantity of patent applications. This effect is also markedly present in the total applications within developed nations, in addition to those originating from non-residents.

To further refine our analysis, we compare the calculated coefficient estimates derived for our yr20 variable with those from the dur and dur_lag variables, proposed by Park. Our investigation reveals that the coefficient estimate for the dur variable yields no statistically significant outcomes. The dur_lag variable procures merely one statistically significant result, specifically for the aggregate number of patent applications in developed nations. This discovery amplifies the reliability of our yr20 variable in contrast with the duration-based variables, underpinning its significance in our analysis. Furthermore, given the presence of several discrepancies identified in Park's construction of the duration component within the Park Index, these outcomes align with our expectations.

Figure 6 present a visual representation of the number of countries that implemented the 20-year patent length rule each year from 1980 to 2020. This analysis is based on data from the three variables yr20, dur and dur_lag. When examining the data for 1980, we observe discrepancies among the variables. Both dur and dur_lag suggest that 24 countries implemented the patent length rule as early as 1980. However, these findings are contradicted by the yr20 variable, which indicates that only 16 countries had actually implemented the rule in that year.

To explain the limited impact and inconsistency in the coefficient estimates of dur and dur_lag, we consider the fact that these variables are only recorded every fifth year. This infrequent measurement interval can introduce inaccuracies in determining the exact year of implementation which is evident in the graphs. One can see abrupt jumps in the number of countries represented by the black and blue dots. Overall, these findings highlight the need for caution when interpreting the data, particularly regarding the year of implementation based on dur and dur_lag variables.

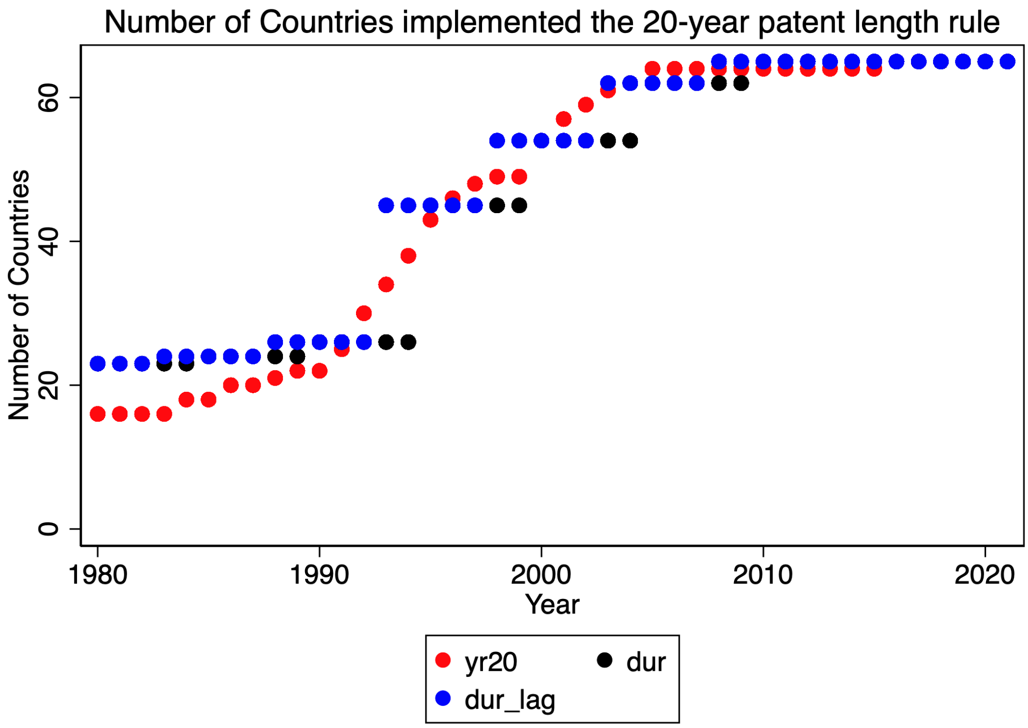

Figure 6: When implemented the 20-year patent length rule

Finally, we examine the control variables incorporated in the study. These are not the central focus but play a crucial role in the integrity and robustness of our results. However, with the use of fixed effects models, it is important to be aware that a country's fixed effects and those that do not vary over time disappear. Additionally, this difficulty may also apply to those with minimal variation over time. Country-specific effects from GDP, GDP per capita, and memberships in international organizations one controls for can then be difficult to measure. Therefore, we interpret the control variables with caution since they change little over time. The interpretations and discussion of the control variables can be found in Appendix 6.

9.2 Additional Discussion

In this section, we extend the scope of our research with a more profound discussion. Our investigation, thus far, has equipped us with key interpretations and a solid grounding. However, we acknowledge the complex nature of our study and realize that there are several layers yet to be explored. Further, the additional discussion pull together more arguments from the interview conducted with economic theory and our own insights.

In our interview with Holen, one of his perspectives centered on two critical issues pertaining to patents: the long-lasting process for approval and the high costs associated with it. We suspect that these challenges could deter potential patents, particularly those in developing countries from seeking protection for their innovations. This difficulty might be due to the significant resources required - both time and financial - to pursue patent rights, which many individuals and firms may not have readily available. Start-ups and smaller companies, who typically operate with fewer resources, may also be particularly affected by these barriers.

Based on Arundel's (2001) theory, such challenges may encourage individuals and businesses to pursue other strategies to preserve their ideas, such as retaining secrecy, rather than seeking formal patent protection. This is an issue that needs to be investigated more, as well as potential policy changes, to guarantee that all inventors have feasible access to patent protection. Nonetheless, we will postpone this additional debate for another time.

Furthermore, we delve into IPRs and their implications. IPRs essentially grant temporary monopolies to patent holders, resulting in a potential deadweight loss within the economy. This topic becomes intriguing when we contrast the overall economic impact with the effects on individual stakeholders such as firms and competitors across diverse markets. Typically, these stakeholders will favor the prospect of establishing their own monopoly, even though society may face a diminished consumer surplus. We explored this concept further in our interview with Holen.

Further on, we posed a crucial question to Holen: "Do the benefits of patents surpass the economic deadweight loss they create?". He asserted that without patents, the drive for innovation will be suffocated, leading to a significant decrease in value creation and creative incentives. He suggested that in a world devoid of patents, everyone would simply imitate each other. Holen's viewpoint provides a crucial perspective from the business community. It suggests that despite initially creating a deadweight loss, patents might spur technological advancement and economic growth by fostering temporary monopolies. This underlines the complex dynamics between IPRs and economic growth.

9.3 Directions for Further Research

Through our research and the challenges encountered, we have identified several potential avenues for future investigation. We offer these suggestions in the hope of advancing the field and addressing some of the unresolved issues that have surfaced in our study.

In our analysis, certain control variables, contrary to our expectations, seemed to have no discernible effect on patent applications, irrespective of a country's developmental status or residency. We believe this may not reflect the true nature of the relationships and can potentially be attributed to simultaneity issues and the nature of FE models. Therefore, future research might consider the use of an Instrumental Variable estimation technique. This approach could potentially address these simultaneity concerns and provide greater clarity on the actual relationships.

Additionally, employing a difference-in-difference (DiD) methodology might offer valuable insights. This approach can designate developing countries as treatment groups and developed countries as control groups, given the notable differences in their respective implementation timelines for the TRIPS agreement. Future research may then leverage either a time variable or another TRIPS compliance variable for the time aspect of the DiD analysis. We believe this approach can be of significant interest to researchers investigating intellectual property rights and the TRIPS agreement, presenting a promising direction for further exploration within this field.

10 Conclusions

In closing up this master thesis, the spotlight returns to the turbulent waters caused by the TRIPS Agreement. This treaty, a well-intentioned attempt to harmonize global intellectual property rights has become a battleground of starkly contrasting perspectives since its establishment. Its ability to encourage new ideas and innovations is often seen in contrast to the argument that it prevents fair and equal access to important knowledge and resources. The TRIPS Agreement clearly highlights this ongoing debate, especially in areas with limited resources.

This study has sought to explore the impact of the controversial TRIPS agreement on patent application trends across developed and developing nations. We embarked on this investigation by analyzing intellectual property rights laws of 68 countries from 1980 to 2021. Our methodology hinged on a fixed effects model employing the patent protection index by W. Park and J. Ginarte (1997), supplemented by insights from G. Holen, the CEO of Nordic Electrofuel.

The results of our analysis show that the TRIPS agreement appears to have a significant positive impact on patent applications from non-residents in developing countries. However, we see little change in the applications from residents. So, the overall increase in total patent applications in these countries seems to be driven mainly by non-residents. This outcome aligns with our initial hypothesis.

Regarding developed countries, we find a slight increase in resident patent applications. Still, the growth of patent applications from non-residents seem more significant following the agreement. This makes it challenging to back up our second hypothesis, which suggested a more substantial increase in resident compared to non-resident patent applications. But, it is important to note that each of these results is backed by only one variable. Hence, we are viewing these findings cautiously.

As we conclude our master's thesis, we anticipate that our investigation into how the TRIPS agreement impacts various patent application measures will supplement future studies on this topic. In addition, we intend to provide a stronger foundation of understanding for future research.

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12 Appendix

Appendix 1: Patent Length of 20 Years

Sources for Finding Years for the Implementation of the 20-year rule

Table 21 below shows an overview of when the different countries implemented 20-years of patent length. We have used the laws of each country as the source for when the implementation years. However, in some circumstances throughout our research, we encountered challenges in determining the specific year of implementation of the 20-year patent length, due to missing information regarding laws and the implementation in some countries. To address this issue, we crossed-checked with four main sources.

Firstly, we utilize a detailed analytical report on patent length regulations, prepared by the World Intellectual Property Organization from 1996. This report provides a timeline of when numerous countries instituted the 20-year patent length rule (WIPO, 1996). It is important to highlight that the report dates back to 1996, so if any country adopted the rule after this year, that information will not be available in this report.

Secondly, another source we cross-check with is an article referred to earlier, written by Arza et. al. in 2023, which provides an overview of various countries' implementation years for the 20-year patent length rule, along with other relevant measures (Arza et al., 2023). However, upon closer examination, we identified several inaccuracies in this article, as our findings revealed earlier instances of the implementation of patent laws for certain countries, contradicting the information presented in the article. Some of these countries are for example Austria, Finland and Norway. In this regard, we note that there are no differences in the years for any of the Latin American countries (in general developing countries), only the rest which in general are European countries (most of them are developed).

The third source is the European Patent Office's website. In the case of Japan, specific details about their patent length regulation were not readily available. Consequently, we turned to the EPO website for information. While the original law was established in 1959, the EPO indicates a revised version was introduced in 1995, which includes the 20-year patent length rule. As we couldn't find this amendment information in the actual law, we considered the credibility and reliability of the EPO as a reputable source. Given that this specific matter pertains only to Japan, we decided to adopt the enactment year provided by the EPO.

The fourth source we use is The European Patent Convention (EPC). This legislation applies to multiple countries in our analysis. The EPC was signed in 1973 and became effective in 1977 (Lovdata, 2022). As a consequence of the legislation, it exist strong indications supporting that many European countries already had implemented the 20-year patent length rule a long time before the TRIPS agreement in 1996. We therefore use the year for signing EPC in the yr20 variable for the following countries: Belgium, France, Germany, Netherlands, Sweden, and Turkey.

Table 21: Timeline of Implementation of the 20-year Patent Length Rule by Country

No.	Country	Year	Corresponding Law or Act
1	Algeria	1966	Ordinance No. 66-54 of 1966, Art. 6
2	Argentina	1995	Law 24,481 on Patents and Utility Models, May 1995.
3	Australia	1995	Patents (World Trade Organisation Amendments) Act 1994 (Cth) s 7
4	Austria	1984	Federal Law of 1970, as last amended by the Law of May 23, 1984
5	Bangladesh		No law yet
6	Belgium	1977	European Patent Convention (1973), in force from 1977
7	Brazil	1997	Law 9729 on Industrial Property, May 1996
8	Bulgaria	1993	Patent Law of March 18, 1993, Art. 16
9	Canada	1989	Patent Act R.S., 1985, as amended by R.S., 1985. Term of patents based on applications filed on or after October 1, 1989
10	Chile	2005	Law No. 19,039 on Industrial Property
11	China	1993	Patent Law of the People's Republic of China, 1992, Article 45
12	China, Hong Kong	1997	Patents Ordinance (Cap. 514), 27 June 1997

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Table 21 continued from previous page

No.	Country	Year	Corresponding Law or Act
13	Colombia	1994	Decision 344 of the Commission of the Cartagena Agreement, Common Regime on Industrial Property. Article 30, 1993
14	Costa Rica	2000	Law No. 6867 of April 25, 1983, on Patents, Industrial Designs and Utility Models, as amended by Law No. 7979 of February 2, 2000
15	Cyprus	1957	Law No. 40 of 1957, Sec. 8
16	Denmark	1986	Patents Act, cf. Consolidate Act. No. 110, 11th March 1986
17	Ecuador	1994	Decision 344 of the Commission of the Cartagena Agreement, Common Regime on Industrial Property. Article 30, 1993
18	Egypt	2002	Law No. 82 of 2002 Pertaining to the Protection of Intellectual Property Rights, Art. 9
19	Finland	1980	Patents Act, 1980/407, Sec. 40
20	France	1977	European Patent Convention (1973), in force from 1977
21	Germany	1977	European Patent Convention (1973), in force from 1977
22	Greece	1988	Law on Technology Transfer, Inventions and Technical Innovation No. 1733/1987 (as last amended by Law No. 1739/1987, November 1987)
23	Guatemala	2001	Industrial Property Law (Decree No. 57-2000), September 2000
24	Honduras	2000	Industrial Property Law , 1999
25	Hungary	1984	Patent Act No. 2 of 1969, as amended by Decree Law No. 5 in 1983 Art. 12
26	Iceland	1992	Patents Act No. 17/1991, December 1991
27	India	2002	Patents (Amendment) Act 2002
28	Indonesia	2001	Law No. 14 of August 1, 2001, regarding Patents. Art. 8
29	Ireland	1992	Patents Act, February 1992

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Table 21 continued from previous page

No.	Country	Year	Corresponding Law or Act
30	Israel	1968	Patents Law 5727, August 1967
31	Italy	1979	R. D. No. 1,127, 1939, as amended by D. P. R. No. 338, June 1979
32	Jamaica	2022	The Jamaica Patents and Designs Act (No.1 of 2020)
33	Japan	1995	Patent Act of 1959, amended in 1995, Art. 67
34	Lithuania	1994	Patent Law (1994), Art. 27
35	Luxembourg	1992	Law on Patents for Inventions of June 30, 1880, Art. 7; Law Amending the patent system of July 20, 1992, Art. 43
36	Madagascar		No law yet
37	Malaysia	2001	Patents Act 1983 Patents Regulations (Amendment) 2001
38	Malta	2003	Patents and Designs Act, Act XVII of 2002
39	Mexico	1991	Industrial Property Law, June 1991
40	Morocco	1941	Decree of 1916, as amended in 1941, Art. 26 and 30
41	Netherlands	1977	European Patent Convention (1973), in force from 1977
42	New Zealand	1995	Patents Amendment Act, December 1994
43	Norway	1979	Patents Act of 1979 (Patentloven). Paragraph 40
44	Pakistan	2000	Patents Ordinance, 2000
45	Panama	1996	Industrial Property, Law, 10/05/1996, No. 35
46	Peru	1994	Decision 344 of the Comission of the Cartagena Agreement, October 1993
47	Philippines	1998	The Intellectual Property Code of the Philippines, 1997, Republic Act No. 8293
48	Poland	1993	Law on Inventive Activity of 1972, as amended in April 1993
49	Portugal	1995	Ministry of Industry and Energy Decree-Law nr 16/95 of 24th January 1995, Art. 94
50	Republic of Korea	1996	Patent Act 950, 1961, Amended by Act No. 5329, July 1, 1996
51	Romania	1991	Patent Law No. 64/1991

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Table 21 continued from previous page

No.	Country	Year	Corresponding Law or Act
52	Russian Federation	1992	Patent Law of The Russian Federation No. 3517-1 of September 23, 1992
53	Saudi Arabia	2004	Law on Patents, Layout Designs of Integrated Circuits, Plant Varieties, and Industrial Designs (2004), Art. 19
54	Slovakia	1991	Law No. 527 on Inventions, Industrial Designs and Rationalization Proposals, November 1990
55	South Africa	1978	Patents Act, 1978. Act No. 57
56	Spain	1986	Law 11/1986 on Patents and Utility Models, March 1986
57	Sri Lanka	2003	Intellectual Property Act, No. 36 of 2003
58	Sweden	1978	European Patent Convention (1973), in force from 1977, member from 1978
59	Switzerland	1977	Federal Law on Patents for Inventions of 1954, as revised in December 1976
60	Thailand	1992	Patent Act B.E 2522 of 1979, as amended in 1992, Sec. 35
61	Tunisia	1939	Decree of 1939, Sec. 1
62	Turkey	2000	European Patent Convention (1973), in force from 1977, member from 2000
63	Ukraine	1994	Law of Ukraine On the Protection of Rights to Inventions and Utility Models, Chapter II Legal Protection of Inventions (Utility Models)
64	United Kingdom	1977	Patents Act, October 1977
65	United States of America	1952	United States Code (U.S.C.), Title 35–Patents, July 19, 1952
66	Uruguay	2000	Law No. 17.164. Invention Patents, Utility Models, and Industrial Designs. Article 124
67	Viet Nam	2005	Intellectual Property Law, Law No. 50/2005/QH11
68	Zambia	2016	The new Patents Act, No. 40 of 2016

Old Soviet States

Various political situations such as the dissolution of the Soviet Union, have impacted the specific years in which countries implemented the 20-year patent length rule. For example, Lithuania, which was formerly a Soviet state, formally implemented the rule in 1994, despite it potentially being in place in the region when it was part of the Soviet Union. Hence, this potential problem is important to consider.

The patent law in the Soviet Union has a complex history, with the first version being established in 1924 and undergoing several revisions over the years. The most recent major revision occurred in 1961, and this version of the law remained in effect until the dissolution of the Soviet Union in 1991. Under Soviet patent law, the term of patent protection was 15 years from the date of filing, although there were exceptions and variations based on the type of invention and other factors relevant to the patent application. In summary, following the dissolution of the Soviet Union, the establishment of several new states occurred, and none of these states had implemented the 20-year patent rule prior to their formal establishment (Blair, 1973). Therefore, the reported years when these new states implemented the rule are accurate.

Appendix 2: Development Status

We have classified all countries into four distinct categories: Developed, Developing, Least Developed or In Transition based on data obtained from the World Economic Situation and Prospects (WESP). Our objective in this categorization process was to capture the fundamental economic conditions prevalent in each country. For the purpose of analysis, we have ensured that each country is assigned to either the category Developed or Developing. It is essential to note that countries defined as Least Developed or In Transition tend to have less advanced economies compared to those in the Developed category. This justifies their classification as Developing. Broadly speaking, our analysis reveals that geographical regions encompassing South, East, and Western Asia, Africa, the Caribbean, and Latin America can generally be classified as developing economies (United Nations, 2014).

Table 22: Development Status for All Countries

Developed	Developing	Least Developed	In Transition
Australia	Algeria	Bangladesh	Russia
Austria	Argentina	Madagascar	Ukraine
Belgium	Brazil	Zambia	
Bulgaria	Chile		
Canada	China		
Cyprus	China, Hong Kong		
Denmark	Colombia		
Finland	Costa Rica		
France	Ecuador		
Germany	Egypt		
Greece	Guatemala		
Hungary	Honduras		
Iceland	India		
Ireland	Malaysia		
Italy	Mexico		
Japan	Morocco		
Republic of Korea	Pakistan		
Lithuania	Panama		
Luxembourg	Peru		
Malta	Philippines		
Netherlands	Saudi Arabia		
Norway	South Africa		
Poland	Thailand		
Portugal	Tunisia		
Romania	Turkey		
Slovakia	Uruguay		
Spain	Vietnam		
Sweden			
Switzerland			
United Kingdom			
United States			

Appendix 3: Discussion of FE and RE models

There are several advantages and disadvantages of using fixed effects models. Employing a fixed effects model makes it feasible to control for time-variant variables, thereby mitigating the issue of spurious relationships, as one yields a more precise estimation of the relationship between the variables x_{it} and y_{it}. This is the best approach if you know or suspect that $\text{cov}(x_1, c_i) \neq 0$ (Mehmetoglu & Jakobsen, 2017, 248). Still, time-invariant variables are omitted when using fixed effects. Additionally, estimating variables that rarely change can be an issue, a problem often occurring within social science (Mehmetoglu & Jakobsen, 2017, 249), as it is in our case.

Even though the rule of thumb for when to choose the fixed effect and random effects model is straightforward, some exceptions can appear. One can still use the random effects model if one has omitted variable bias (OVB). The reason is that OVB might cause $\text{cov}(x_1, c_i) \neq 0$ and a RE model can then be used together with including additional explanatory variables (Mehmetoglu & Jakobsen, 2017, 251). In our opinion, we include the most essential and relevant explanatory variables that might occur as omitted variables if not included in the regression analysis. Still, we can not rule out completely that we have no OVB, as we are investigating a quite complex question.

Another aspect to investigate concerning choosing FE or RE models is whether one has time-invariant explanatory variables of significant theoretical importance. If this is the case, the intercept can absorb these variables and force one to use RE models (Mehmetoglu & Jakobsen, 2017, 251).

Initially in our analysis, we included a time-invariant dummy variable for treatment, which was crucial for examining the impact of the TRIPS agreement. This variable identified countries with low patent protection ($PI < 2.5$) that significantly increased their protection level ($PI > 2.5$) during our study period, indicating a "treated" country. It was represented as a binary variable, taking a value of 1 if a country exceeded the threshold and 0 otherwise.

However, we encountered a challenge when using fixed effects models with time-invariant explanatory variables. To address this issue, we transformed our treatment variable(s) to be time-variant, allowing us to capture the changes in the PI over time.

This modification enabled us to incorporate the dynamic nature of the treatment variable(s) in our analysis.

Comparisons of the RE and FE coeffient estimates are shown in Table 23, 24 and 25 below. One can see that the coefficient estimates in the RE models are more extreme, which is often a typical feature when comparing FE and RE models (Cameron et al., 2010, 252).

Table 23: Model Comparisons for All Patent Applications and in Developed and Developing Countries

Variables	FE all.	RE all.	FE dev.	RE dev.	FE dev.ing.	RE dev.ing.
PIhigh	0.5899***	0.4879***	1.2867***	0.8302**	0.3254***	0.3099***
	(0.1099)	(0.1086)	(0.2977)	(0.2891)	(0.0790)	(0.0797)
lGDP	0.0774	1.0074***	-0.3918	1.0228***	0.3560	0.9585***
	(0.1943)	(0.0453)	(0.3130)	(0.0558)	(0.2532)	(0.0760)
lgdp_cap	0.7370**	-0.1214	1.4730***	-0.0121	0.8094*	0.0730
	(0.2352)	(0.0683)	(0.3480)	(0.1133)	(0.3526)	(0.1087)
openess	-0.0001	-0.0001	-0.0045***	-0.0047***	0.0000	0.0000
	(0.0001)	(0.0001)	(0.0007)	(0.0006)	(0.0001)	(0.0001)
PCTyr	-0.4523***	-0.5224***	-0.7794***	-0.5548**	-0.4251***	-0.4761***
	(0.0809)	(0.0771)	(0.1923)	(0.1798)	(0.0621)	(0.0612)
EPOyr	-1.4155***	-1.4200***	-1.3065***	-1.2832***	0.0823	-0.0464
	(0.0710)	(0.0673)	(0.0937)	(0.0864)	(0.1564)	(0.1554)
invest	0.0138***	0.0114**	0.0020	0.0029	0.0100*	0.0127**
	(0.0038)	(0.0038)	(0.0056)	(0.0056)	(0.0047)	(0.0045)
RD	0.2609***	0.2728***	0.3627***	0.3439***	0.0949	0.1259*
	(0.0514)	(0.0480)	(0.0753)	(0.0708)	(0.0543)	(0.0521)
_cons	-1.2216	-17.5749***	3.7533	-18.8128***	-8.6367*	-18.0883***
	(3.0988)	(1.0294)	(5.2018)	(1.4591)	(3.7637)	(1.5030)
Observations	1329	1329	823	823	439	439

Standard errors in parentheses. Abbreviations: all. = all applications, dev. = developed, dev.ing. = developing.

* Significant at 10% (p < 0.10)

** Significant at 5% (p < 0.05)

*** Significant at 1% (p < 0.01)

Table 24: Model Comparisons for All Patent Applications in Developing Countries from Residents and Non-Residents

Variables	FE Res	RE Res	FE Non-Res	RE Non-Res
PIhigh	-0.0992	-0.0986	0.4024***	0.3866***
	(0.1235)	(0.1233)	(0.0993)	(0.0994)
lGDP	1.3585***	1.2424***	0.3030	0.9159***
	(0.3094)	(0.1414)	(0.2413)	(0.0767)
lgdp_cap	0.0568	0.1717	0.4956	-0.0697
	(0.4109)	(0.1910)	(0.3098)	(0.1052)
openess	-0.0001	-0.0001	0.0001	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
PCTyr	-0.2334*	-0.2102*	-0.3045***	-0.4089***
	(0.0984)	(0.0956)	(0.0779)	(0.0747)
EPOyr	1.5967***	1.5469***	-1.8488***	-2.0457***
	(0.2401)	(0.2378)	(0.1947)	(0.1909)
invest	-0.0027	-0.0009	0.0072	0.0052
	(0.0062)	(0.0062)	(0.0050)	(0.0049)
RD	0.0267	0.0983	0.0450	0.0643
	(0.0791)	(0.0759)	(0.0637)	(0.0587)
_cons	-29.5898***	-27.7720***	-4.7403	-15.8826***
	(4.8335)	(2.5638)	(3.8519)	(1.5333)
Observations	466	466	494	494

Abbreviations: Res = Resident, Non-Res = Non-Resident.

Standard errors in parentheses.

* Significant at 10% ($p < 0.10$)

** Significant at 5% ($p < 0.05$)

*** Significant at 1% ($p < 0.01$)

Table 25: Model Comparisons for All Patent Applications in Developed Countries from Residents and Non-Residents

Variables	FE Res	RE Res	FE Non-Res	RE Non-Res
PIhigh	0.0547	-0.0614	1.2241**	0.4880
	(0.2543)	(0.2504)	(0.4366)	(0.4146)
lGDP	0.5453*	1.2294***	0.6104	0.8660***
	(0.2765)	(0.0769)	(0.4747)	(0.0694)
lgdp_cap	0.5633	-0.1518	-0.6830	-0.1523
	(0.3061)	(0.1264)	(0.5256)	(0.1497)
openess	-0.0007	-0.0015*	-0.0046***	-0.0052***
	(0.0007)	(0.0006)	(0.0011)	(0.0009)
PCTyr	-0.4673**	-0.4119**	-0.5728*	-0.0801
	(0.1647)	(0.1588)	(0.2828)	(0.2554)
EPOyr	-0.5448***	-0.4555***	-2.1942***	-2.5244***
	(0.0811)	(0.0774)	(0.1393)	(0.1244)
invest	0.0003	-0.0003	0.0361***	0.0262**
	(0.0052)	(0.0052)	(0.0089)	(0.0086)
RD	0.3420***	0.3838***	0.2092	0.1468
	(0.0656)	(0.0639)	(0.1126)	(0.1011)
_cons	-12.6855**	-23.8888***	-2.6756	-14.0594***
	(4.6068)	(1.6721)	(7.9106)	(1.9487)
Observations	793	793	793	793

Abbreviations: Res = Resident, Non-Res = Non-Resident.

Standard errors in parentheses.

* Significant at 10% ($p < 0.10$)

** Significant at 5% ($p < 0.05$)

*** Significant at 1% ($p < 0.01$)

Appendix 4: Interview Guide

We start the interview process with an introduction part, asking Holen about his background and his role in the company. We present ourselves and give information about our thesis and what kind of questions we will ask. Further, we inform about the potential consequences of participating and how we document the interview content. We ask him whether he approves that we (the interviewers) take notes and record the interview. Finally, we inform Holen that we will delete the recording and the notes when the thesis is finalized. As it is important to guarantee anonymity or make an agreement on permission to use data, Holen have signed a consent form. This can be found in the attachments. We provide him information on his rights to quit the interview whenever he wants and give a time perspective for the interview length.

Further, the key questions should take up over half of the interview time and require elaboration. Finally, the interview round off by giving Holen the opportunity to give additional information he believe is relevant. Creating an interview guide that facilitates this creates a natural and logical progression with some overlap between the different subjects. This can be followed with some flexibility in the way that there is room for some changes during the interview (Tufte et al., 2016, p. 148). Table 26 to 28 below show the interview guide in Norwegian, reflecting the language spoken during the interview.

Table 26: Interview Guide - Introduksjonsspørsmål

Nummer	Spørsmål
1	Hva heter du og hva er din rolle i Nordic Electrofuel?
2	Hva er din faglige og profesjonelle bakgrunn?
3	Hva driver Nordic Electrofuel overordnet med? Hva er firmaets historie?
4	Hva er dine fremtidige mål for Nordic Electrofuel?

Table 27: Interview Guide - Utdypende spørsmål

Nummer	Spørsmål
5	Hva er deres teknologi?
6	Hvilke erfaringer har du med implementeringen av patenter? Vi ser at dere har patent for en Pox-rwgs reaktor, some er knyttet til hydrokarbon produksjon. Det virker også som at dere har søkt patent for E-fuel 1 med PTL. Status? Det ser ut som det tok to år fra dere søkte om det første patentet til det ble invilget. Hva tenker du om denne tidsrammen?
7	Har du noe forhold til TRIPS avtalen? Stimulerer TRIPS til økonomisk utvikling slik du ser det?
8	Synes du det er dyrt å patentere? og fornyelse av patenteringen?
9	Hvordan stiller du deg til følgende: "Oppfinnelser som patenteres i de fleste land og med lengst patent lengde er de mest verdifulle patentene."? Hvordan verdsetter du patenter?
10	Hva mener du er fordeler og ulemper med patentering sammenlignet med andre alternativer?
11	Hvorfor har dere valgt å patentere deres innovasjon?
12	Har du noen bekymringer ift. at informasjon om innovasjonen deres blir offentlig når det patenteres (at andre kan utnytte informasjonen)?
13	Har dere vurdert å beskytte innovasjonen deres med hemmelighold i stede for patentering?
14	Vi ser fra årsregnskapet deres fra 2021 at dere hadde 62,5 mill. i FoU kostnader i 2021. Hva er deres FoU kostnader nå og hva tror du de blir i framtiden? Har dere nok investeringer for å bygge og produsere drivstoffet deres? I hvor stor grad påvirker det deres fremtidige utvikling av nye teknologier/forbedringer som muligens kan patenteres?
15	Tror du de bedriftene som investerer mest penger i R&D får flere innvilgelser per søknad? Eventuelt hvorfor/hvorfor ikke?
16	I hvilke land har dere søkt patentbeskyttelse i og fått innvilgelse i? Hvordan er planen for fremtidige patentsøknader?
17	Hvor lenge ønsker dere å ha patenene (patent lengde)? Hvordan vurderer dere dette?

Continued on next page

Table 27 – continued from previous page

18	Tror du at IPR (immaterielle rettigheter) stimulerer til kreativitet? Hvorfor/hvorfor ikke?
19	Synes/tror du det er lettere å få patentsøknader godkjent i andre land enn sitt eget? påvirker svaret FDIs (utenlands direkteinvesteringer)? Påvirker politiske forhold hvor lett det er å patentere i andre land (f.ex. regulerer noen land IPR strengere enn andre?)
20	IPR skaper midlertidige monopoler, pga. at patenteringer er eksklusive rettigheter til de/dem som eier dem. Dette fører til dødvektstap i økonomien. Hva er ditt syn på spørsmålet: Mener du nytten av patenteringer er større for samfunnet enn dødvektstapet?
21	Synes du IPRs er regulert for strengt, svakt eller er det godt nok slik det er nå?

Table 28: Interview Guide - Avsluttende spørsmål

Nummer	Spørsmål
23	Hvilke patentkontorer har du vært i kontakt med?
24	Hvilke erfaringer har du med samspillet mellom deg og patentkontorene i Norge og utlandet?
25	Er det noen andre erfaringer eller annen informasjon du vil dele i forhold til teamet?

Appendix 5: Data Collection, Legal and Ethical Regulations

General Data Protection Regulation (GDPR)

When collecting data for our thesis, we want to have a strong focus on ethics as well as compliance with legal regulations. Therefore, we want to be conscious about how we use and present data. In this regard, following the General Data Protection Regulation (GDPR) is desirable and important. This is a law the European Union (EU) has adopted and that applies to all members of the EU and the European Economic Area (EEA) (NHO, n.d.). The EU's data protection law (GDPR) was established in 2016 and has for a long time been viewed as a golden standard all over the world. The GDPR replaced the Protection Directive from 1995, which was established at a point in time when the internet was developed in a very early phase, and with low significance on the protection of data digitally, compared to today. Hence, GDPR takes today's modern internet and technology into account (European Data Protection Supervisor, 2018).

Ethical regulations

In relation to ethics, we want to listen carefully to the interview object and respect his preferences when regarding how we can use data obtained from them. This can be i.e. the interview object wants to be anonymous or that they only want us to use some data. Therefore, before we carry out interviews we should agree on what guidelines and framework conditions should apply. This includes that all parties (researchers and the interview object) sign a consent form.

There are research ethical guidelines in relation to research on the internet, developed by NESH. This concerns internet culture, consumer behavior online, and research that uses the internet as a tool in their research, for example, finding informants to interview via the internet. Research through the Internet underlies the same ethical demands and guidelines as other research. Still, there are some special considerations one must be aware of because of the internet's peculiarity. For example, it can be hard to distinguish between public and private information online. As a rule of thumb, online information can be used without consent as we account for it being public. Still, researchers should consider this aspect, as some information is of a pretty private character. Another aspect is that if one uses information from the internet, it can be hard to collect consent. Therefore, it is important to provide information about where the information is taken from and referencing it (Tufte et al., 2016, 87).

Researchers' ethical and juridical responsibility

We aim to follow ethical research guidelines developed by The National Research Ethics Committees for social science and humanities. These are described in detail below.

1. ***The informants' right to self-determination and autonomy:*** The one that is being asked, the one participating, and the one that has participated in former research should decide on their participation. The person concerned should give explicitly informative and voluntary consent to participation and should have the right to withdraw without any form of discomfort or get negative consequences at any point in time (Tufte et al., 2016, p. 86).

2. ***The researcher's duty to respect the informants' privacy:*** Participants should have the right to decide who gets insight into their lives and what gets out of the information. The person concerned should have the right to deny researchers access to information about themselves and should control how and what information about them is public or available to others. They should be sure that the researchers attend to confidentiality and don't use the information so that the people involved in the research can be identified (Tufte et al., 2016, p. 86).

3. ***The researcher's responsibility of avoiding damage:*** One has to consider whether collecting data, for example through interviews, can affect vulnerable and sensitive areas that can be hard to process and get out of. The one participating should be postponed to as little strain as possible (Tufte et al., 2016, p. 86).

Responsibilities when doing research

In the process of conducting research, considering ethics in handling and utilizing collected information is vital. It is also crucial to comply with the established laws and regulations pertaining to data usage. As such, we employ P. A. Tufte's

”Introduksjon til Samfunnsvitenskapelig Metode” as a fundamental reference to guide our understanding of these critical aspects.

Ethics is about principles, rules, and guidelines for assessing whether actions are right or wrong. All actions that have potential consequences for others should be judged based on ethical standards (Tufte et al., 2016, p. 83). Therefore, gaining an understanding of ethical standards is crucial for the development of this thesis.

Ethical issues arise when research directly affects people, especially when collecting data through interviews or experiments (Tufte et al., 2016, p. 84). In some interviews, the informants might feel that they say something wrong, given too much information, or that the interviewer has treated the interview object with little respect. Then, one should consider one’s behavior regarding whether the interview has been conducted ethically or not. Further, what can be done to avoid such incidents again? (Tufte et al., 2016, p. 84).

When collecting data, we comply with the Norwegian Act of Processing Personal Data (Personopplysningsloven). According to this law, personal protection is a person’s right to privacy and the right to decide over their own personal data. Hence, if you want to collect information about people, you have to (1) have a lawful reason, (2) permission, (3) pay attention to their registration, and (4) ensure safe treatment of the collected information. When examining, one must clarify if personal data can identify individuals directly (e.g., name or address) or indirectly (e.g., a combination of information of an individual) and if these are sensitive (e.g., health condition, ethnic background, or political stand) (Tufte et al., 2016, p. 88-89). When we use personal information, we are responsible for knowing how to deal with the rules. We consider how the information should be secured concerning confidentiality, integrity, accuracy and availability. If the research contains information that does not identify individuals, even directly or indirectly, the persons are anonymous and the Norwegian Act of Processing Personal Data does not apply (Tufte et al., 2016, p. 89).

The Norwegian Act of Processing Personal Data requires consent to participate in research if individuals can be identified. This must be voluntary, explicit, and an informed statement from whom the information regards that the person consents to the usage of the information about themselves. In addition, all information that can be connected to individuals is confidential. Results from projects that contain personal information must be anonymized. Also, the information that is being collected through research, should only be used for the purpose that the data is collected for, not in any other circumstances (Tufte et al., 2016, p. 90). As we conduct an interview we attach a consent form, signed by us (the researchers) and the interview object G. Holen.

Appendix 6: Discussion of Control Variables

When using a fixed effect model, the effects of the control variables need to be interpreted with caution. Further, we aim to interpret the coefficient estimates of the control variables. The alleged impacts are illustrated in Table 29 below.

Upon examination of the coefficient estimates for each country's market size, we find support for our suspicion that larger markets get more patent applications only in the total applications to developing countries. This result is evaluated to be of little practical significance, which is supported by reflections from our interview with Holen. Holen described the dilemma concerning the number of markets in which one should seek patent protection. Apart from his home country, Norway, he indicated that Nordic Electrofuel targets patent applications in larger markets, given the rich opportunities these markets generally offer, as well as the probability of greater markets attracting more industries.

Furthermore, we propose that larger markets, particularly within sectors like energy, have the potential to create significant location advantages. Such markets attract a variety of businesses, fostering competitive industry clusters that stimulate collaboration and growth. These clusters not only provide innovation activities but also promote the sharing of ideas and resources. Furthermore, larger markets can have a greater pool of talent and capital - two essential components for business expansion and innovation. With a wider range of skills and increased funding available, companies can effectively execute their innovative ideas. These insights provide support to the small practical significance of GDP's inconclusive result.

Table 29: Summary of Coefficient Estimates from Control Variables in Developing and Developed Countries, Also Divided into Applications from Residents and Non-residents

Variable	All	Developing			Developed		
		Tot	Res.	Non-Res.	Tot	Res.	Non-Res.
lGDP	-	↑	-	-	-	-	-
lgdp_con	-	-	-	-	-	-	-
openess	-	-	-	-	-	-	-
PCTyr	↓	↓	-	↓	-	-	-
EPOyr	↓	-	-	↓	↓	↓	↓
invest	-	-	-	-	-	-	↑
R&D	↑	↑	-	-	-	↑	-

All = All applications, Tot = Total applications in developing/developed countries, Res. = Residents, Non-Res. = Non-residents.

Note: The symbols ↑, ↓, and - represent positive effect, negative effect, and no effect respectively.

The timing of a country's membership in the PCT appears to have a negative impact on all patent applications, on those in developing countries, and on those from non-residents. Hence, it seems like PCT membership only affects applications in developing countries, not in developed ones. One possible explanation for the discrepancy is the variation in the timing of PCT signing among countries. Most developed countries joined the PCT around 1980. In contrast, many developing countries became members around 1995 (WIPO, n.d.-b). This means that most developed countries have been members throughout the whole dataset horizon while developing only half. As a result, the variable representing the signing of the PCT year may capture the effect of being economically disadvantaged or less developed, rather than solely measuring the actual content of the PCT. This may explain why we observe the impact of PCT primarily in relation to patent applications directed toward developing countries.

Our analysis of countries' membership status in the EPO yields some unexpected findings. We discover that EPO membership seems to have a notably negative impact on the number of patent applications, shown in 5 out of 7 regressions. This is surprising, as we initially believed that EPO membership potentially increase some types of patent applications.

We discussed the EPO coefficient estimates with the NIPO. It looks like a country becoming an EPO member and entities wishing to file a patent within Europe (covering EPO members) tend to file their applications directly to EPO instead of the countries' patent offices. This is subsequently affirmed by Bjørn Lillekjendlie from NIPO in an email dated the 4th of June 2023. He indicates that to a certain extent, the number of patent applications to a country may decrease for this reason. Consequently, the inclusion of the EPO variable may potentially bias the resulting coefficient estimates for EPO. Therefore, it is not essential to concentrate heavily on the estimates for the EPO variable.

In our interview with Holen, we got insight supporting our belief that EPO membership could boost patent applications, particularly in developed European countries. Holen emphasized the practical advantage of dealing with a single patent office, like the EPO. This streamlined approach simplifies the application process and covers significant markets, which may attract applications. Indeed, this is a key reason why Nordic Electrofuel has filed patents in Europe. Given these considerations, we question the practical implications of our discovery that EPO membership is associated with a decrease in overall patent applications.

The impact of R&D expenditures on patent applications appears to be limited, mainly affecting overall applications, those in developing countries and resident applications in developed countries. Greater investments in R&D can foster innovation (Cohen et al., 2002) and the subsequent protection of these innovations through patents. Therefore, it is not surprising that increased resources allocated to R&D may lead to more patent applications (Griliches, 1984, p. 3).

Another potential reason for the limited impact of R&D expenditures is that they are primarily used within a country's borders. Both private and public entities utilize these funds (The World Bank, n.d.-d). Consequently, the amount of R&D expenditures does not directly impact non-residents. Also, the lack of effect on resident applications in developing countries may be attributed to the low productivity of R&D in such nations (The World Bank, n.d.-d). For instance, residents may lack the capacity to fully leverage the resources provided for research and development. These resources can be allocated toward imitations rather than the development of new technologies (Mansfield et al., 1981). For these reasons, a lack of discovered effect is reasonable.

We believe that GDP per capita, open economies and high investments may positively influence economic growth and thereby attract patent applications. Surprisingly, we do not find any support for this, a result we evaluate to have little practical importance. This can be due to a potential simultaneity problem hindering us from finding true relationships. In turn, this can inflate the standard errors, diminishing the statistical power to identify significant effects (Wooldridge, 2018, p. 534). Thus, our data might not reveal clear relationships, but the practical significance of these variables should not be overlooked.

Further, we emphasize a problem of multicollinearity between GDP per capita and R&D. This may be an explanation for the limited impact of GDP per capita and R&D expenditures independently on various measures of patent applications. The interpretation is backed by having a moderate correlation (0.65) as discussed earlier. This may result in biased coefficient estimates and impedes our ability to assess the effects of variable changes.

Lastly, it is important to note that the above-mentioned issues are not our primary concern, as our main goal in this thesis is to evaluate the effects of the explanatory variables.