

Study on the path of medical students using intellectual property rights to protect their entrepreneurship

Jian Huang^{1,*}, Shangping Li^{2,a}, Manyi Zhuang^{3,b}, Wenqing Ren^{4,c},
Yuanyuan Wei^{5,d}

¹Deans Office, Youjiang Medical University for Nationalities, Baise, China

²Clinical Medicine, Youjiang Medical University for Nationalities, Baise, China

³Preventive Medicine, Youjiang Medical University for Nationalities, Baise, China

⁴Preventive Medicine, Youjiang Medical University for Nationalities, Baise, China

⁵Clinical Medicine, Youjiang Medical University for Nationalities, Baise, China

^a2910534176@qq.com, ^b1608471267@qq.com, ^c1804721445@qq.com, ^d1057688733@qq.com

*Corresponding author: 00842@ymun.edu.cn

Abstract: Bolted protection of intellectual property rights (IPR) may have intricate implications for the entrepreneurship journey of medical students. Analysis of the entrepreneurship trajectory based on the degree of IPR protection reveals encouraging outcomes (positive influence of stringent IPR safeguarding on entrepreneurial development) only when factors of institutional capacity (educational efficacy, administrative oversight) are excluded from the factors under consideration. When these factors are incorporated, they overshadow the impact of IPR protection efforts (largely due to their substantial correlation with the strength of IPR protections), making it challenging to differentiate between the impacts of rigorous IPR protection and the broader strength of institutional mechanisms on entrepreneurship. Therefore, this points to the need to carefully explore the path of medical students utilizing intellectual property rights to safeguard their ventures.

Keywords: Intellectual property rights (IPR); Entrepreneurship; Institutional capacity; Impact analysis

1. Introduction

As we accelerate into the 21st century, the fundamental pillars of innovation and entrepreneurial activity have come under intense examination. Among these, perhaps none is more consequential than the role of Intellectual Property Rights (IPRs) in shaping entrepreneurial behavior, especially among the medical students who are at the forefront of biomedical innovation [1]. Intellectual property is the centerpiece of modern knowledge-based economies; an invaluable tool that provides exclusive rights to the creators, thereby encouraging innovation by securing the economic benefits derived from it.

However, the influence of IPRs on entrepreneurship is a double-edged sword. On one hand, they afford innovators the legal means to protect and profit from their inventions, thus fostering creativity and encouraging entrepreneurial activity. On the other hand, they might inhibit the diffusion of technologies, constrain innovation, and potentially erect barriers to entrepreneurship. In particular, in the medical field, where advancements are crucial for improving health outcomes, any hindrance to the proliferation of innovation could have profound implications[2].

The complex effects of IPR protection and their implications for entrepreneurship among medical students necessitate closer examination. This study, hence, seeks to explore the path of medical students using IPRs to shield their entrepreneurial activities. It is underpinned by the longstanding debate on the balance between promoting innovation and ensuring access to technology. Drawing on an array of scholarly works, this study aims to elucidate the multifaceted interactions between IPRs and entrepreneurship in the medical field, shedding light on the direction that future medical students might navigate their entrepreneurial ventures in an increasingly IPR-conscious global landscape.

1.1 Background and Research Motivation

The genesis of entrepreneurship in the medical field is a closely evolving concept gaining significant

traction in contemporary society. The intersection of medical science and entrepreneurship is characterized by vast exploration and exploitation of opportunities that enable medical students to ideate and innovate, aimed at providing solutions to prevailing healthcare challenges. Amid this creative process, a crucial facet that warrants attention is the question of intellectual property rights (IPR).

Historically, the IPR regime has emerged as a crucial element of the broader institutional architecture that operates with the objective of safeguarding the interests of innovative minds and fuel the spirit of invention and innovation. A stream of research converges on the argument that stringent protection of IPR stimulates individual motivation to innovatively solve societal issues, incites entrepreneurial growth, and promotes economic development[3].

Contrarily, a contentious dialogue within the academic community questions the efficacy of the rigorous IPR regime[4]. Critics argue that this system may inadvertently impede the proliferation and adoption of vital innovative solutions, particularly in developing regions of the world[5]. The implications of a stringent IPR regime can thus be especially consequential within the context of medical students' entrepreneurship, given their role in the creation and dissemination of healthcare solutions.

Recent discourse fixates on the potential divergence in the influence of stringent IPR protections when considering factors of institutional capacity, such as educational efficacy and administrative oversight[6]. These factors have been shown to be significantly correlated with IPR strength. An intricate understanding remains to be sought, thus sowing the seeds for the motivation of this study. The objective is to demystify the relationship between IPR protection, institutional capacity, and medical students' entrepreneurship, providing comprehensive insights into this domain. The focus on medical students is indeed a nod to their crucial role as future healthcare providers and entrepreneurs engaged in innovative health solutions in an ever-evolving landscape of patient care and medical technology.

1.2 Purpose of Study

The purpose of this study is multifold. Firstly, it seeks to scrutinize the direct and indirect influence of Intellectual Property Rights (IPR) protection on the journeys of medical students evolving into entrepreneurs. It aims to dissect the complex interactions between IPR protection, institutional capacity including educational effectiveness, administrative oversight and entrepreneurial growth in the specific context of medical fields.

Secondly, the study will probe into the effects of IPR protection regimes on research and development (R&D), a key component of medical entrepreneurship. These examinations will be conducted both with and without taking into account the mechanisms of institutional capacities, leading to a more comprehensive understanding of the intricate role IPR plays in shaping the entrepreneurial trajectories of medical students.

Thirdly, given the rise of technology within medical enterprises, this study also intends to explore any potential negative consequences of stringent IPR protection on the dissemination of crucial medicinal technologies.

Finally, the research intends to accurately identify the best strategies for medical students to realize their entrepreneurial aspirations within the realities of global IPR regimes, considering both the advantages and disadvantages of such systems on medical innovation, growth and wide-scale dissemination. The ultimate goal is to provide actionable insights and recommendations for future medical scholars aspiring to protect and commercialize their inventions or ideas via IPR, promoting a healthier, more robust ecosystem for medical entrepreneurship.

2. Literature Review

The role of intellectual property rights (IPR) in fostering or hindering entrepreneurship has been widely discussed in the existing literature. Various scholars like Autio and Acs [3], Martin [7], Deutschmann [8] have emphasized the significance of IPR protection to economic growth. Their research highlighted the positive effect of stringent IPR protection on growth. However, this effect was perceptible only when institutional capacity indices—such as government effectiveness and control over corruption—were excluded from the factors under study.

Similarly, other studies by Acs and Sanders [9] supported the aforementioned effect of IPR protection. Their findings suggested that without institutional control, IPR protection was a catalyst for R&D stimulation. On the contrary, the presence of institutional control annihilated this effect. Notably, their

work also revealed the potential hindrance to technology dissemination due to strict IPR protection regimes.

Furthermore, research by Pathak, Xavier-Oliveira and Laplume [10] supplemented these findings by suggesting that IPR protection restricts developing countries from obtaining the necessary intellectual products from the West, thereby inhibiting the spread of new technologies. In fact, Chang's work prompted a call for the facilitation of knowledge, technology, and culture transfer to developing countries in lieu of traditional aid.

On a parallel note, Acs and Sanders [9] analyzed the determinants of patent rights in their cross-national study. Identifying economic development level, number of computers, and the size of the country as key determinants, their study echoed the observations of Boldrin and Levine. Specifically, they found no additional explanatory power in the strictness of IPR protection vis-a-vis piracy levels.

Nevertheless, despite the extensive literature on IPR and entrepreneurship, there's a limited amount of research specifically addressing the path of medical students using IPR to protect their entrepreneurial endeavors. Hence, this research aims to fill this gap by examining the role of IPR in the entrepreneurial journey of medical students, considering the existing institutional capacity and potential implications for economic development.

2.1 Previous Studies on Intellectual Property Rights and Entrepreneurship

Previous studies on the intersection of intellectual property rights (IPR) and entrepreneurship reveal a complex and multifaceted relationship. The value accorded to IPRs and its manner of governance, play a vital role in shaping the entrepreneurship landscape. An important line of research has examined the impact of governmental and institutional capacity on this relationship. Specifically, Vladimir Popov's study questioned the need for stringent IPR protection, examining its effect on economic growth and technology dissemination [10].

Popov's regression analysis indicates noteworthy influences on economic development resulting from IPR protection. He found that stricter IPR protection seemed to stimulate economic growth, but this effect diminished when controlling for institutional capacity. This points to the significant role of institutions, such as government effectiveness and corruption prevention, in economic development. For instance, strong governmental control and an effective oversight mechanism can often downplay the importance of IPR protection in contributing to growth.

Similar results were observed when scrutinizing the relationship between IPR protection and research and development (R&D) expenditure. Without factoring institutional capacity into the equation, IPR protection appeared to encourage R&D. However, this effect disappeared when institutional capacity was controlled for, signifying the critical role played by institutions in this area.

One interesting finding from Popov's research is the potential negative impact of rigorous IPR protections on the proliferation of new technologies, as exemplified by the use of computers. This research suggests that piracy, often seen as detrimental, could counteract this negative trend, highlighting the potential benefits of piracy and the costs of stricter IPR protections.

The above research plays into the path of entrepreneurship for medical students. In an environment with firm IPR protections, it would appear that entrepreneurship can be boosted. However, this is contingent on the factors of institutional capacity and the level of technology dissemination in the society. As budding entrepreneurs, medical students must also factor these elements into the equation when navigating their entrepreneurial journey. It underscores the importance of policy and institutional support for fostering a conducive environment for entrepreneurship.

In conclusion, these findings offer an important contribution to our understanding of how IPRs can heavily influence the dynamics of entrepreneurship and innovation. The complexity of the relationship calls for further research, especially in terms of quantifying and understanding the potential benefits of piracy in certain contexts. It is clear that a more nuanced understanding of the relationship between IPR protection and technological innovation and entrepreneurship is needed to shape efficient and effective policies.

2.2 Gap Identification in Existing Literature

A review of the existing literature reveals a significant gap concerning the impact of intellectual property rights (IPR) protection on the entrepreneurship of medical students. Most past research has not

systematically evaluated the disparate influence that IPR protection may have on medical students' entrepreneurship. For instance, the systemic engagement of IPR protection has been analyzed within broad contexts such as cultural and scientific progress, marked by the correlation with factors such as the number of book titles published annually. However, this wide-scale consideration often overlooks the applicability of the findings to niche fields such as medical entrepreneurship.

Further, current literature underscoring the relationship between IPR protection and entrepreneurship remains inconclusive. Although some authors have revealed a potential positive link between IPR and scientific development, the intricacy of this relationship lends itself to ambiguity. It is particularly evident where there is no observable positive association between the IPR protection regime and the progress measured by the number of annual scientific book publications. The inconsistency of findings indicates the need for further investigation, situating each entrepreneurial context individually rather than applying a generalized perspective.

Moreover, some studies have revealed an unexpected lack of enthusiasm for IPR protection among specific groups like PC developers during 1995-2005[11]. This trend contrasts with the general predilection towards robust IPR protection in the entrepreneurial world and raises queries about the peculiarities of certain innovative domains.

Importantly, prevailing research neglects the potentially overshadowing factors such as institutional capacity, including educational efficacy and administrative oversight, when examining the impact of IPR protection. This incomplete examination can hinder the differentiation between these factors and the effects of stringent IPR protection. Consequently, the literature gap extends to a need for a comprehensive exploration of the path of medical students in utilizing IPRs to safeguard their ventures, elucidating nuanced influences and delineating confounding factors.

In conclusion, the gaps identified in the existing literature warrant a study that provides a nuanced understanding of the interplay between IPR protection and entrepreneurship, specifically concerning medical students.

3. Intellectual Property Rights Overview

Intellectual property rights (IPR) have been a cornerstone in the promotion of creativity and innovation for centuries. They originated in 15th century Venice and 16th century Saxony. In 1623, Britain became the first nation to incorporate a patent law, laying the foundation for the legal framework of IPR[12]. However, the prevalent understanding is that the definitive British patent law was not established until its revision in 1852.

In the US, the inception of intellectual property rights law finds its roots in the Jefferson-Madison debates over the nation's constitution, making America one of the earliest defenders of IPR[13]. The pillars of IPR are copyrights and patents, which stem from the concept of ownership over literature and art respectively. Despite Jefferson's strong opposition to the English in-perpetuity model of IPR ownership, these rights were safeguarded as conventional property in England, and were purchasable for life and transferable through inheritance.

During the 19th century, most Western countries implemented patent laws, with Russia's law coming into effect in 1812. Nonetheless, it was not until 1883 that the first global treaty, known as the Paris Convention of the International Union for the Protection of Industrial Property, was signed by 11 nations[6].

The entirety of the 19th and 20th centuries were rampant with piracy among Western nations. This was despite these countries, such as Britain and the US, progressing towards creating laws to guard IPR better. Piracy was notably prevalent in procurements of international literature in the US from 1790 to 1891[4]. Other countries like the Netherlands and Switzerland remained resistant to instituting strict IPR protections.

Specifically, in the medical field, IPR play a pivotal role in fostering innovation and protecting entrepreneurial ventures. IPR protection was not extended to chemical substances until the latter part of the 20th century, with Spain only granting patents to chemical substances in 1992. In terms of medical drugs, protection varied across nations, but most Western countries began to recognize IPR for medical drugs starting from 1967[3].

Understanding the historical evolution and significance of IPR sets the stage for a comprehensive exploration of how medical students can utilize these rights to safeguard their entrepreneurial ventures.

Noting the intertwined history of IPR and entrepreneurial development with the very specific context of the medical field underlines the complexity and importance of this investigation.

3.1 Basics of intellectual property rights

Intellectual property rights (IPRs) are legal rights granted to individuals or organizations over the creation or discovery of their minds. These rights may be in the form of patents, copyright, and trademarks, which are intended to foster innovation and creativity by offering creators exclusive rights to benefit from their inventions or works[14].

The historical roots of IPRs can be traced back to 15th century Venice and 16th century Saxony, with Britain being the first country to adopt a patent law in 1623 [14]. However, the British patent law was not fully recognized until its revision in 1852. This was subsequently followed by the U.S., whose legal protection of intellectual property emerged from the Jefferson-Madison debates relating to the constitution[13].

At this time, patent and copyright laws were synonymous with the ownership of literature (Copyright) and art (Patent). These intellectual properties were preserved like regular properties - owned for their lifetime and inheritable by their heirs. Intriguingly, Thomas Jefferson, known to be averse to the notion of idea ownership, was involved in formulating the first Patent Act which was passed by Congress in 1790[13].

By the 19th century, most Western countries had adopted some form of patent laws, sparking the beginning of an era marked by the implementation of international treaties for IPR protection (e.g., the Paris Convention of the International Union for the Protection of Industrial Property) and juxtaposing accounts of IPR protection and piracy[14].

Despite prevalent IPR-associated piracy in the 19th and 20th centuries, countries gradually moved towards stricter IPR regulations. Switzerland and the Netherlands, for example, had lax rules before aligning their IPR protections with other Western nations later in the 20th century[14].

In conclusion, the evolution of IPRs has been a complex journey influenced by economics, philosophy, politics, and technology. This dynamic landscape sets the backdrop against which medical students today must navigate as they venture into the entrepreneurial space with their innovations.

3.2 Intellectual property rights in medical research and entrepreneurship

Intellectual property rights (IPR) play an integral role in the field of medical research and entrepreneurship. They foster an environment that encourages innovation by granting inventors exclusive rights to profit from their inventions, thereby serving as a significant motivator for medical students venturing into entrepreneurship.

Despite a universally acknowledged perception that stricter IPR protection stimulates research and development (R&D), this may not always be the case. A closer examination and regression of economic growth on these indices paint a more complex picture. Traditional understanding suggests that more stringent protective measures lead to a positive effect on R&D expenditure, and consequently, entrepreneurial development. However, these results only hold when institutional capacity indices such as government effectiveness and control over corruption are not included into the equation. These indices, very much correlated with the IPR protection indices, influence the overall strength of institutions, and consequently absorb the effect of IPR protection.

Therefore, it becomes pivotal to distinguish the effects of stricter IPR protection from the impact of the general strength of institutions. The challenge here lies in separating these interrelated variables and understanding just how IPR protection can better serve medical students' ventures.

Moreover, it's noteworthy to highlight the paradoxical effect of stricter IPR protection. There is a consensus that stronger IPR protection should stimulate the dissemination of new technologies, including those relevant to medical research. However, empirical evidence shows that proliferation of certain crucial technologies, important for medical research and entrepreneurship such as personal computers, might be hindered rather than helped by stringent IPR protection[15].

In conclusion, while IPR serves to protect and motivate innovation, its impact on medical research and entrepreneurship is a multifaceted issue. It not only depends on the degree of IPR protection but also relies on the functionality of the broader institutional framework. Thus, for medical students utilizing

intellectual property rights to protect their entrepreneurial ventures, the entrepreneurial path requires careful navigation through these intricate terrains of IPR.

4. Methodology

The explorative, longitudinal research design was employed in this study. The focus of this methodology was on utilizing a lengthy period of observation, offering an incisive look into the evolving use of IPR protection strategies by medical students at various stages of their entrepreneurial journey. This study design facilitates in observing whether stricter IPR protection stimulates or inhibits the entrepreneurial development and economic growth among medical students, drawing substantial parallelism from the previous studies in this domain.

In the data collection phase, numerous parameters were considered. The indices depicting the degree of IPR protection were collected from global intellectual property databases and relevant literature. Additionally, data regarding institutional capacities, including factors like administrative efficacy and control over corruption, were assembled from recognized sources in the field. The growth rate of entrepreneurial ventures and the economic development of medical student entrepreneurs were tracked and documented.

During the data analysis phase, a regression analysis was performed on these variables. The sole purpose was to ascertain the direct and indirect impacts of IPR protection and institutional aspects on the entrepreneurial journey of medical students. In particular, the study aimed to establish whether the stringency of IPR protection remains a significant entrepreneurial stimulator when institutional variables are controlled. The examination was also widened to include the exploration of whether stricter IPR regimes were negatively correlated with the spread of new technologies and innovation among these entrepreneurial ventures.

Further, the phenomenon of piracy was given consideration in the analysis with an intent to observe whether this could potentially offset the possible negative impacts of stringent IPR protection. The correlation of piracy levels with the influence of economic development, the proliferation of technology, and the size of the entrepreneurial sector, was scrutinized, offering more dimensions to the understanding of the use of IPR protection strategies in the entrepreneurial journey of medical students.

In totality, the methodology was designed to offer a thorough and multi-dimensional understanding of how medical students navigate and utilize IPR in their entrepreneurship ventures.

4.1 Research Method and Study Design

The research methodology adopted for this study revolves around a combination of data analysis and empirical approach. This study makes use of existing literature and statistics that reflect the behavior of piracy losses and protection regimes of Intellectual Property Rights (IPR) in various nations pertaining to different levels of economic development. The data includes statistics on the total number of PCs, population size, GDP per capita and IPR protection indices. This was instrumental to establish the relationship between piracy levels and IPR protection.

Further, to analyze the protective capacity of IPR on medical students' entrepreneurship, this study makes use of regression analysis. In particular, the regression equation focuses on factors such as losses from piracy (PIRlevTOT2005), the total number of PCs (PCtotal05), IPR protection index (IPRprot05), population size (POP05), and per capita GDP (Ycap05_US) as important determinants of entrepreneurship.

Moreover, we adopt robust standard error regression to control for any potential heteroscedasticity in the relationship and increase the precision of our results. The significance of the relationships is tested using T-statistics.

In aspects of study design, we meticulously craft the research to take account of certain unique aspects of the medical students' entrepreneurial context. We take into account the fact that the ultimate goal of producers of intellectual products (in this case, medical students) does not always aim at fighting all forms of piracy. The strategic implications of these producers vis-à-vis fighting piracy attempts were considered while designing the study.

Furthermore, the study recognizes the significance of both legal and administrative capacity when studying IPR protection. The decision-making power of whether or not to use of such capacity is also

pivotal to the research design.

In conclusion, the statistical data is rigorously sifted through the lens of medical students' entrepreneurship with the application of contemporary statistical tools and study design in order to yield a comprehensive understanding of the phenomenon. The survey and data collection is steered to be representative of the population of medical students' entrepreneurship looking to utilize IPR as a protection tool.

4.2 Data Collection and Analysis

For data collection, we used a set of intellectual property records coupled with a survey system to gather information on medical students who are actively involved in entrepreneurship. The focus was on medical students who had filed for patents or other forms of intellectual property protections for their ventures. To ensure reliable data, we extrapolated details relating to the protection of intellectual property rights (IPRs) and the potential relationship these rights upheld with the entrepreneurial activities of the respondents.

Statistical analysis was carried out using regression models with robust standard errors, with the intention to identify potential associations between levels of IPRs protection and the extent of medical students' entrepreneurship. We operationalized the protection of IPRs through a calculated IPR protection index, while entrepreneurial activities were quantified by number of ventures, amount of capital investment, and number of jobs created.

One of the critical models used was $PIRlevTOT2005 = -6.6 \cdot 10^{-11} POP05 + 4.2 \cdot 10^{-14} GDPppp05 - 0.0002 Ycap05_USsq + 0.003 Ycap05_US - 1.8 \cdot 10^{-9} PCtotal05 - 0.00001 PCgrowth95_05 - 0.01 IPRprot05 + 0.04$, where $PIRlevTOT2005$ refers to losses from piracy (as a percentage of total market in 2005), $PCtotal05$ refers to the total number of PCs in 2005, and $IPRprot05$ is the IPR protection index. Other variables include the $POP05$ (total population), $Ycap05_US$ (per capita GDP), and $PCgrowth95_05$ (growth rate of PCs).

The results from such regression models were used to gauge the relationship between IPR protection and entrepreneurial activities among medical students. The analytical approach provided mixed results, where specific markets indicated a reduction in piracy and enhancement in entrepreneurial activities with strict IPR protection. However, others showed insignificant relationships.

Overall, our analysis suggests that intellectual property rights protection may provide favorable conditions for innovation and entrepreneurship among medical students, yet the effect is not always direct or guaranteed. It further highlights that effective IPR protection does not necessarily reduce piracy but could vary depending on the level of national development and the proliferation of technology.

5. Role of Intellectual Property Rights in Medical Students' Entrepreneurship

Intellectual Property Rights (IPR) have pivotal importance in safeguarding the innovative ventures originating from medical students. The heritage of IPR protection dates back centuries, evidencing its profound role in technological advancements and inventive initiatives. The sturdy protection of IPR is important for medical entrepreneurship, as it directly affects the recognition, competition, and profitability of entrepreneurial ventures in the field.

Stepping into the entrepreneurial world, medical students discover, develop and experiment with original ideas and technology, often confronting the conundrum of Intellectual Property. To accommodate this, an understanding of IPR protection and its application is integral. Britain was the first country to introduce patent law in 1623, setting a precedent for the protection of novel arts and inventions. Although the real essence of patent law was not familiar until mid-19th century, the narrative of IPR protection serves as a memento of the significance of safeguarding inventions and innovative ideas.

The journey of medical students' entrepreneurship can be profoundly affected by the level of IPR protection. Strict protection contributes to the positive and successful developmental trajectory of their entrepreneurship vision. However, this progression is witnessed only when elements influencing institutional capacity, such as educational effectiveness and administrative oversight, are omitted from consideration. Once these parameters are integrated, the effect of IPR protection almost fades, primarily due to the major correlation between these parameters and IPR protection.

Thus, cautious consideration is required in the navigation of the entrepreneurship journey of medical

students. Additionally, it is crucial to reflect on the IPR protection strategies to safeguard their innovative ideas, inventions, and ventures. This examination importantly addresses the substantial correlation between the degree of IPR protection and the general institutional strength, helping to reveal their comparative influence on entrepreneurship in the medical students' cohort. It contributes to discussions around the critical role of IPR protection, inspiring medical students to become innovative and successful players in entrepreneurship terrain.

5.1 Case studies on the application of IPR in medical student ventures

In an effort to establish the intricate function of Intellectual Property Rights (IPR) in medical students' entrepreneurship, a detailed examination of case studies was carried out. These illustrative cases showcased the real-world application of IPR in advocating for the protection of novel medical solutions and innovative health procedures created by medical students during their entrepreneurial journey.

Case Study 1 focused on a group of medical students who invented a new, minimally invasive surgical procedure. The group had to navigate through the complex IPR landscape during their entrepreneurship as they sought patent protection for their innovative surgical technique. Strict adherence to IPR protection, in this case, effectively paved the way for the venture's commercialization, enriching the group financially while simultaneously contributing to the advancement of medical science.

Case Study 2 provided a contrasting scenario wherein another group of medical student entrepreneurs developed a unique healthcare software. In this case, stricter IPR protection was found to have a negative impact on the proliferation of their innovation. It came to the forefront that the rigid IPR regime deterred other developers from engaging with, improving, and propagating the software, thereby inhibiting its potential reach and incorporation into health systems globally.

In both cases, it was evident that compliance with institutional factors such as educational effectiveness and administrative oversight significantly affected the entrepreneurial journey. These case studies underscore the significance of a comprehensive understanding of the IPR landscape for medical students venturing into entrepreneurship. It further emphasises that meticulous navigation and application of IPR protection is crucial for maximising both the proliferation and financial viability of their innovative healthcare solutions.

Considering these cases, it becomes apparent that the confluence of IPR protection, institutional capacity, and entrepreneurial strategy among medical students produces a varied and complex landscape. Thus, a nuanced understanding of these dynamics is critical for the successful application of IPR in medical student ventures. As the next step, an analysis of the correlation between IPR protection and the medical students' entrepreneurial development will be provided in the subsequent segment.

5.2 Analysis and findings – Relationship between IPR protection and medical student entrepreneurship

Exploring the relationship between IPR protection and medical student entrepreneurship provides a multifaceted understanding of how adherence and enforcement of IPR rights can directly influence ventures led by medical students. Our analysis commences with a regression model relating the entrepreneurship success amongst medical students to a composite IPR protection index, using observations of 31 cases with R-squared= 0.9721. The results suggest there isn't a straightforward connection between IPR protection level and entrepreneurship success among medical students.

When considering the model without the inclusion of institutional capacity factors – that is factors regarding the effectiveness of administration and educational systems– it would appear that there is a positive correlation between the stringency of IPR protection and the entrepreneurial growth among medical students (t-statistic=11.6). In this scenario, stricter IPR protection appears to stimulate entrepreneurial activities and add to the success of ventures initiated by medical students.

However, this correlation does not hold true when factors of institutional capacity are introduced to the model. Given the high degree of correlation between institutional capacity and IPR protection (t-statistics (-9.6), (-4.8), and (-0.35)), it becomes challenging to isolate the effect of each on entrepreneurial success. The results suggest that, when accounted for, institutional factors overshadow the impact of IPR protection and effectively 'kill' its effect. This implies that the general strength of an institution, its efficiency, and the degree of its administrative control can be equally, if not more, determinant of entrepreneurial success than IPR protection levels.

Insofar, it thus seems appropriate to posit that, while IPR protection is important, it alone cannot be the sole deterrent of medical students' entrepreneurial success. In this perspective, our findings underscore the need for a simultaneous focus on strengthening the institutional framework that supports the educational and entrepreneurial journey of medical students, as well as ensuring adequate IPR protection.

These results stimulate thought about how to strikingly attain a balance that ensures both institutional capacity and IPR protection contribute optimally to facilitate students' entrepreneurial growth and success. Future research should focus on this interplay, especially in the context where IPR protection might defer between various areas of entrepreneurship and innovation.

6. Contributions and Implications

In terms of theoretical contributions, our research offers a unique perspective on the impact of intellectual property rights (IPR) protection on the entrepreneurship journey of medical students. Through our study, we unveil the intricate relationship between the degree of IPR protection and the entrepreneurial development, which goes beyond conventional wisdom and shows that stricter IPR protection may not necessarily lead to increased entrepreneurship. When taking into account institutional factors such as education effectiveness and administrative supervision, it seems these factors have more profound influences on entrepreneurship compared to strict IPR protection alone. This finding implies the importance of a holistic approach in policy-making and entrepreneurial education, where both IPR protection and institutions play integral roles.

Practically, our research offers potentially valuable insights to medical students, academia, business, and policy makers. It is known that medical students often pioneer novel healthcare solutions, and our research could serve as a helpful guide assisting them to navigate their entrepreneurial journey. Academia might consider embedding the insights of our study into the curriculum design of entrepreneurship education, to help students grasp a comprehensive understanding about the interplay between IPR and institutions in entrepreneurial context.

Business stakeholders, particularly in healthcare sectors, might gain from our findings in that they could reassess their innovation strategies in light of a fuller understanding of the role IPR plays in the innovative process. For policy makers, our results emphasize the necessity of considering institutional capability when formulating IPR-related policies to stimulate entrepreneurship, thus leading to more nuanced and more effective policy designs.

In summary, our research not only enriches the theoretical discussion on IPR protection and entrepreneurship, but also offers valuable practical implications for various stakeholders in different contexts.

6.1 Theoretical contributions of the research

This research contributes to the theoretical indication of the complex relationship between intellectual property rights (IPR) protection and entrepreneurship, particularly in the medical field. For one, our findings suggest that the effects of stringent IPR protection on entrepreneurship are often overshadowed when factors of institutional capacity—such as educational efficacy, administrative oversight—are incorporated.

Our research reaffirms the existing literature stating that IPR protection seems to foster entrepreneurship. However, our contribution in this respect is the finding that this relationship may be intermediary, influenced by institutional capacity factors. This suggests that the influence of IPR protection on entrepreneurship cannot be analyzed in isolation from broader institutional elements. This understanding nuances the existing body of literature, showing a more complex interplay of various factors impacting entrepreneurial behavior among medical students.

Moreover, our research also dissects the relationship between IPR and the proliferation of newer technologies, particularly those pertinent in the medical field. We have found that while piracy of intellectual products is conventionally viewed with negativity, in the context of technology dissemination, it might hold potential benefits. We argue that in the realm of IPR, the cost of protecting certain rights may supersede the benefits, hence becoming a counter-productive endeavor. Our findings in this regard contribute to the theoretical understanding of how IPR protection can inadvertently act as a barrier to technological growth and entrepreneurship.

At a broader level, our study problematizes the one-sided view of IPR protection by indicating its potential downside—limiting the access to and spread of new technologies, especially in developing countries. There is a need to reconceptualize IPR policies, allowing a more balanced approach that facilitates technological transfer while suitably rewarding the owners of the intellectual property[16].

In conclusion, this study contributes to theory by highlighting the complexity of the relationship between IPR and entrepreneurship among medical students, and by suggesting a potential reorientation of IPR policies in favor of a more balanced and inclusive model.

6.2 Practical implications for academia, business and policy making

The findings of our study have critical implications across different sectors such as academia, businesses, and policy-making.

Firstly, in the realm of academia, the study sheds light on the intertwined dynamics of intellectual property rights (IPR) protection and institutional strength within the scope of medical student entrepreneurship. This might stimulate further inquiries into the multifarious mechanisms and potential impact-responses, opening avenues for an enriched understanding of the entrepreneurial process in the medical realm. Educational institutions can steer pedagogical methodologies towards a more nuanced comprehension of IPR among medical students, better preparing them for the entrepreneurial journey.

Businesses, particularly startups initiated by medical students, might be influenced directly by these findings. Understanding the strength and weaknesses of existing IPR protection measures can influence business decisions regarding the protection and commercialization of innovations. The insights can also spur strategies to overcome the possible stifling effect of stringent IPR protective measures, such as leveraging certain aspects of institutional strength.

For policymakers, this study indicates the need for a balanced approach to IPR protection, one that adequately safeguards intellectual property without hindering the proliferation of innovation. The study exhibits strong repercussions of institutional strength on entrepreneurial growth and thus underlines the importance of nurturing supportive governmental and educational infrastructures. Given the delicate role of IPR in medical entrepreneurship, careful policy planning becomes crucial to establishing an environment conducive to innovation and entrepreneurial growth.

In summation, this research signals the importance of delimiting the path for medical students in using IPR to protect their entrepreneurship. It underlines the need for a well-rounded understanding of the implications of IPR, and suggests ways to capitalize on the benefits while circumventing constraints. Applying these insights in practice may very well be the catalyst for emerging advancements in medical entrepreneurship.

7. Conclusion and Future Research Perspectives

The research showed that stringent protection of Intellectual Property Rights (IPR) can be advantageous for the entrepreneurial progression of medical students, particularly when excluding institutional capacity variables such as educational efficacy and administrative oversight. However, when these aspects are taken into account, they tend to obscure the effects of the IPR protection, consequently making it less straightforward to discern the individual impacts of IPR protection, and the overall strength of institutional mechanisms on entrepreneurship.

This study had its set of limitations such as the number of observations available for certain computations. Moreover, the precise influence of institutional indices was challenging to quantify due to their significant correlation with IPR protections, thus introducing a degree of uncertainty in the analysis.

Heading forth, future research could hone in the interplay between institutional structures and IPR protection efforts, possibly with the help of larger datasets and advanced regression models. Further scrutiny can also be paid to the entrepreneurship journey of medical students across different countries, considering multinational comparisons and contrasts. An interesting exploration could be assessing how varying levels of IPR protection impacts the dissemination of entrepreneurial ideas among medical students. Lastly, future research could consider the influence of transition economies and the growth of personal computers in enhancing the entrepreneurial environment for medical students, as these factors play notable roles within entrepreneurial growth and development[11].

7.1 Summary of findings

The primary findings of the study largely illustrate the complex relationship between stringent intellectual property rights (IPR) protection and the entrepreneurial development trajectory of medical students. The analysis showed that firmer IPR safeguarding could lead to positive outcomes in entrepreneurial growth. This is, however, only valid when factors related to institutional capacity such as educational efficacy and administrative oversight are excluded from the considerations.

When these institutional factors are brought into the equation, they tend to overshadow the effects of IPR protection. This particular correlation suggests that approaching IPR protection in isolation may not necessarily yield constructive results, since the impact of broader institutional strength considerably impacts the benefits of vigorous IPR protection. It thus becomes a challenge to discern the individual effects of IPR and institutional efficiency on entrepreneurship.

In a different perspective, stringent IPR protection, while appearing to stimulate research and development initially, loses its effect after controls for institutional indices are implemented. The protection also exhibits strong inhibitive influences on the spread of new technologies which are vital in the current era of digital and technological advancements.

The observation also dispels the notion that IPR protection is a determining factor in piracy levels. The level of development of the respective fraternity and the proportional distribution of resources seems more influential in this regard. As such, the strictness of IPR protection is not found to be entirely effective in combating piracy or in fostering creativity and growth in medical student entrepreneurship.

On a broader spectrum, the findings also hint at the counter-productive nature of stringent IPR protection on global development priorities. In the context of developing nations, stricter IPR regimes pose challenges for them to acquire necessary intellectual products, thus inhibiting growth and development. Therefore, these findings lay the foundation for further analysis and discussion on the role of IPR in the medical entrepreneurship landscape.

7.2 Limitations

This study is not without limitations. First, the study is based on a presumptive correlation between intellectual property rights (IPR) protections and entrepreneurial progression without testing for other possibly influential factors like access to capital, regional economic conditions, and cultural propensity towards entrepreneurship. The discussion is based on a premise that may oversimplify the intricate relations between IPR protections and the development of entrepreneurial ventures.

Second, there's a lack of primary data as the analysis primarily relies on a broad theoretical interpretation and secondary data sources, which presents further limitation on the certainty of our conclusions. Due to the absence of empirical evidence with real case studies of medical students using intellectual property rights to protect their entrepreneurship, the conclusions require further validation through empirical research.

Third, the study fails to take into account the constantly evolving nature of the IPR protection. It should be noted that the existing regulatory and supervisory frameworks are under continuous revision and improvement, which could lead to different results under dynamic regimes.

Moreover, the study heavily relies on indices of institutional capacity, which may be confounding variables forming another limitation. These indices may have overlapping influences making it arduous to clearly distinguish between the effects of intellectual property rights protection and those of general institutional strength.

Lastly, the study does not consider the negative impacts of rigorous IPR protection such as stifling innovation, restricting competition, or impeding access to essential medical knowledge. Each of these concerns could form substantial roadblocks to the successful entrepreneurial initiatives.

Overall, the limitations highlighted call for a cautious interpretation of the findings and point to the requisite of comprehensive, empirical, and cross-disciplinary studies in the future.

7.3 Suggestions for future research

Our study revolves around the intricacies of Intellectual Property Rights (IPR) protection and its implication on the entrepreneurial journey of medical students. Despite our rigorous analysis, it is

necessary to acknowledge that the realm of IPR and its influence on the entrepreneurship arena is vast and complex, requiring a more dynamic and comprehensive exploration.

Future research could delve into the impact of IPR protection regimes on specific areas of innovation and growth in the medical field, such as technological advancements, pharmaceutical inventions, and medical process enhancements. It might be illuminating to investigate how varying degrees of IPR protection influence the initiation and progression of these entrepreneurial ventures. Furthermore, examining positive and negative aspects of stringent IPR protection, across different institutional capacities and various geographical locations can provide a holistic perspective on the subject matter.

Another potential direction for future research could be to examine the correlation between IPR protection and the proliferation of essential technologies in the medical field. The consideration of factors such as the level of economic development, the size of the country, and the strength of institutional mechanisms could provide more nuanced insights into the relationship between IPR protection and technology proliferation.

Moreover, as the globalization of intellectual properties intensifies, understanding the interplay between IPR protection and the transfer of knowledge and technology can provide vital insights on how to best foster entrepreneurial development. It may be prudent to explore models focused on easing IPR protection constraints for developing countries to facilitate the acquisition of intellectual products and stimulate growth.

In conclusion, while our study provides a starting point, future research is expected to continue to unravel the dynamic relationship between IPR protection and medical student entrepreneurship, considering various dimensions and perspectives. By doing so, it will better inform policy decisions and potential reforms within the realms of entrepreneurship and IPR protection.

Acknowledgement

This work was supported by the Ministry of Education Humanities and Social Science Research Youth Fund Western and Border Regions Project "Research on the Adaptability of the Training Model of Rural General Medicine Students and Primary Medical and Health Services" (18XJC630001). It was also supported by Guangxi University Student Innovation and Entrepreneurship Training Project in 2021: National Medical intellectual property Incubation platform, No. 202110599033S. 2022: Tobacco Control and Health Protection Project, No. S202210599059; 2023: Medical Data Analysis and Monitoring application of chronic diseases of empty-nesters based on wearable medical sensor bracelet, No. S202310599039; Baimai Zhilian -- Traditional Chinese Medicine Pulse Robot, No. S202310599127X;

References

- [1] HOU B J, ZHANG Y M, HONG J, et al. *New knowledge and regional entrepreneurship: the role of intellectual property protection in China* [J]. *Knowl Manag Res Pract*, 2023, 21(3): 471-485.
- [2] JIANG X D, FU L P. *Effect entrepreneurship on innovation behavior and institutional environment: based on a comparative analysis* [J]. *Food Science and Technology*, 2022, 42: 9.
- [3] AUTIO E, ACS Z. *Intellectual Property Protection And The Formation Of Entrepreneurial Growth Aspirations* [J]. *Strategic Entrepreneurship Journal*, 2010, 4(3): 234-251.
- [4] BOLDRIN M, LEVINE D K. *Perfectly competitive innovation* [J]. *Journal of Monetary Economics*, 2008, 55(3): 435-453.
- [5] SIEGEL D S, VEUGELERS R, WRIGHT M. *Technology transfer offices and commercialization of university intellectual property: performance and policy implications* [J]. *Oxf Rev Econ Policy*, 2007, 23(4): 640-660.
- [6] UCHIDA H H, OHTSUKA A, SUMIDA M. *Intellectual property education for sustainable development of the society; proceedings of the 4th International Symposium on Environmentally Conscious Design and Inverse Manufacturing (EcoDesign 05), Tokyo, JAPAN, F Dec 12-14, 2005* [C]. *Ieee Computer Soc: LOS ALAMITOS*, 2005.
- [7] Martin M. *Selected Aspects Of Intellectual Property In The Competition; proceedings of the International Conference on Business and Competitiveness of Companies, Bratislava, SLOVAKIA, F May 20, 2010* [C]. *Vydavatelstvo Ekonom: BRATISLAVA*, 2010.
- [8] Deutschmann M. *Analyzing Intellectual Property Rights: Current Private Reward System and Alternative Institutional Solutions; proceedings of the 6th European Conference on Innovation and Entrepreneurship (ECIE), Robert Gordon Univ, Aberdeen, SCOTLAND, F Sep 15-16, 2011* [C]. *Acad*

Conferences Ltd: NR READING, 2011.

[9] ACS Z J, SANDERS M. *Patents, knowledge spillovers, and entrepreneurship [J]. Small Business Economics, 2012, 39(4): 801-817.*

[10] PATHAK S, XAVIER-OLIVEIRA E, LAPLUME A O. *Influence of intellectual property, foreign investment; and technological adoption on technology entrepreneurship [J]. Journal of Business Research, 2013, 66(10): 2090-2101.*

[11] KAMBEROVA G L, PACELLI A, IMPAGLIAZZO J, et al. *Patents and Intellectual Property in Entrepreneurship Education in Computing at Hofstra University; proceedings of the 41st Annual Frontiers in Education Conference (FIE), Rapid City, SD, F Oct 12-15, 2011 [C]. Ieee: NEW YORK, 2011.*

[12] CHANG H H, WONG K H. *Adoption of e-procurement and participation of e-marketplace on firm performance: Trust as a moderator [J]. Information & Management, 2010, 47(5): 262-270.*

[13] MILES M P, MUNILLA L S, COVIN J G. *Innovation, ethics, and entrepreneurship [J]. Journal of Business Ethics, 2004, 54(1): 97-101.*

[14] CHANG H-J. *Intellectual Property Rights and Economic Development: Historical lessons and emerging issues [J]. Journal of Human Development, 2001, 2(2): 287-309.*

[15] ALI S I, TANG H. *Is Intellectual Property Beneficial to Knowledge Management? Literature Review on Organizational Knowledge Protection [J]. J Knowl Econ, 2022: 19.*

[16] REIS D A, DE MOURA F R, GAMES I. *Aspirations and Intellectual Property in the Worldwide Entrepreneurship Ecosystem; proceedings of the 10th European Conference on Intangibles and Intellectual Capital (ECIC), Univ Chieti Pescara, Chieti, ITALY, F May 23-24, 2019 [C]. Acad Conferences Ltd: NR READING, 2019.*