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Open Innovation Intellectual Property Risk Maturity Model: An Approach to Measure Intellectual Property Risks of Software Firms Engaged in Open Innovation

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Abstract: Open innovation (OI) is key to sustainable product development and is increasingly gaining significance as the preferred model of innovation across industries. When compared to closed innovation, the protection of intellectual property (IP) that is created in open innovation is complex. For organisations engaging in OI, a sound IP management policy focusing on IP risk reduction plays a significant role in ensuring their sustained growth. Assessing the risks that are involved in IP management will enable firms to devise appropriate IP management strategies, which would ensure sufficient protection of an IP that is created in an OI model. Studies indicate that the risks which are associated with IP and risk management processes also vary with company segments that range from start-ups to micro, small, medium, and large organisations. This paper proposes an open innovation IP risk assessment model to compute the open innovation intellectual property risk score (OIIPRS) by employing an analytic hierarchy process. The OIIPRS indicates the IP risk levels of an organisation when it engages in open innovation with other organisations. The factors contributing to IP risk are identified and further classified as configurable IP risk factors, and the impact of these factors for the various company segments is also factored in when computing the OIIPRS. Further, an OI IP risk maturity model (OIIPRMM) is proposed. This model depicts the IP risk maturity of organisations based on the computed OIIPRS on an IP risk continuum, which categorises firms into five levels of IP risk maturity. The software firms can make use of the OIIPRMM to assess the level of IP risk and adopt proactive IP protection mechanisms while collaborating with other organisations.

Keywords: open innovation intellectual property risk score; open innovation intellectual property risk maturity; open innovation; intellectual property risks; IP risk management; analytic hierarchy process; conceptual model

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1. Introduction

Innovation is the catalyst in the growth and success of any business. Innovative businesses create more efficient work processes and achieve better productivity and performance than do their peers. Innovating in a business can conserve time and money and render a competitive advantage that grows the business in the marketplace [1–5]. Continuous innovation is critical for creating repeated success for sustainable product development.

Different classifications for innovation exist based on the scope of the innovation, the actors who are involved in the innovation, the product of the innovation, etc. [6,7]. One of the most widely used classifications is that which is based on the parties that are involved in the innovation process [8]: (i) closed innovation and (ii) open innovation. Innovation within a firm without any transfer of knowledge from external sources or involvement

from external parties is known as closed innovation. Until the year 2000, companies used closed innovation approaches by restricting innovation to within the organisations [8]. However, in the early 2000s, firms started collaborating with external parties such as customers, suppliers, consultants, universities, and competitors to co-create products and services. Such collaborative efforts with external parties created a new business model, which is known as 'open innovation'. Ref. Chesbrough [8], who coined the term open innovation (OI), defined it as the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. The business model of OI is gaining popularity across all industrial segments. Studies indicate that adopting OI business models enables the growth of the business, and it fosters a culture of innovation [9]. However, there is a growing concern about protecting intellectual assets and potential value-sharing amongst collaborating firms when they open up to OI [10].

Several studies emphasise the significance of the protecting of IP in an OI setting. Much of the research on OI is related to the effect of OI on a firm's performance. Among them, a large amount of the research is focused on the manufacturing, pharma, and telecommunication industries. In the software industry, OI is gaining traction; however, studies that focus on OI and studies that assess the level of IP risk in OI are limited.

This research aims to analyse and identify the various factors that contribute to an organisation's IP risk while engaging in OI. This paper proposes a model to assess the varying levels of IP risk across company segments such as start-ups, micro, small, medium, and large organisations in the software industry. A tool that aids organisations in assessing and measuring IP risk enables them to manage and protect their IP better. Further, following the capability maturity model and risk management maturity model, an OI IP risk maturity model is proposed. This model presents the IP risk score of a firm with varying levels of maturity in IP risk management. Assessing the levels of IP risk and understanding the organisation's position based on the IP risk score enables organisations to devise strategies to lower IP risk and protect their assets as they collaborate with other organisations and co-create products and services.

The related theoretical background, which covers the significance of IP management in OI and the factors that contribute to the IP risk of organisations that engage in OI, is discussed in Section 2.1 under Section 2. The objectives of this study and its methodology, the configurable risk factors for better IP protection, the model for IP risk assessment, and the IP risk maturity model are then discussed. The results of this study, including the varying levels of IP risk score across various company segments, are subsequently discussed selecting Fintech firms from India. Further, how the insights that are gained by measuring the level of IP risk in OI would benefit the firm and the stakeholders when this proposed model is used is discussed in the Conclusions section. The scope for future research in IP management in OI is also discussed.

2. Materials and Methods

The theoretical background, research gaps, and the methodology adopted for this research work are discussed in this section. Further, the models proposed as part of this study are discussed.

2.1. Literature Review

The management of IP and the enforcement of rights play a crucial role in protecting the rights of innovators [11]. The need for IP management in OI has been researched by several scholars. The literature review in this paper is organised into four sections. In Section 2.1.1, the need for and the significance of IP management in OI are discussed. OI in the software industry is then discussed in Section 2.1.2 and the factors that lead to IP risk while engaging in OI are discussed in Section 2.1.3. Research gaps are discussed subsequently in Section 2.1.4.

2.1.1. IP Management in OI

Although OI is on the rise, the level of IP filing has not declined [12]. The worldwide filing of patents increased by 3.6%, with 3.4 million patent applications, and trademarks by 5.5%, with 18.1 million trademark applications in 2021. Asia emerged as the hub for global IP filing activity, with China topping the list at 1.58 million patent filings (an increase of 5.9%) and 9.45 million trademark filings (an increase of 1.2%). India filed 61,573 patents (an increase of 8.5%) and 488,526 trademark applications (an increase of 15.1%) in 2021.

Several researchers have established the need for IP protection in OI [10,13–25]. The significance of IP protection in an OI setting is also emphasised in several studies. A study conducted amongst Swedish manufacturing firms found that firms consider it more critical to patent when they are engaged in OI than in closed innovation [17]. In the UK, nearly 90% of firms that are active in OI regard patents as an essential method to signal the nature of their technological capabilities [22]. A study which was conducted in the Middle East and in Europe established that firms engaging in OI would be involved in IP assignment and acquisition activities [10].

Firms that view IP as an opportunity to create value and build the innovation ecosystem consider IP as an enabler for OI [25,26]. The protecting of IP enables inter-organisational innovation processes by protecting the rights of collaborating firms [15,27–29]. A rise in the strength of IP protection in OI enables free sharing and dissemination of technological information. It also promotes various forms of technology trade [18,30]. Therefore, OI communities and commercial firms have a reason to use the IPR institution in place to protect their innovation systems [15].

While strong levels of IP protection do stifle OI, in the absence of this protection firms may resort to secrecy [31] to protect their innovation. This is a situation that not only hinders OI but negates it [10]. However, the protection of IP in OI is complex due to many factors such as (i) the existence of several business models for collaboration and subsequent revenue generation/sharing, (ii) the involvement of external actors in the OI ecosystem, (iii) a lack of proper policies that govern the OI model, (iv) differences in the existing laws that offer protection in case of cross-border collaboration, and (v) the associated complexities in managing and enforcing IP rights [10,13,25,26,32,33].

2.1.2. OI in the Software Industry

Much of the research conducted in OI that is related to IP management is generic. However, certain research works have focused on specific requirements for the manufacturing [17], pharmaceutical [10], and telecommunications industries [33]. In the software industry, for instance, innovation tends to be highly incremental and cumulative, in which case essential licensing to use an innovation is more likely to involve many patents [15]. Due to the specific needs of IP protection in the software industry, this research focuses on the software industry, specifically, the financial technology industry, in which the largest extent of OI currently occurs [34].

Financial technology firms, also known as FinTechs, which is an umbrella term that is used to describe innovative technology-enabled financial services business models, are inducing a paradigmatic shift in the manner in which financial service firms deliver pecuniary and non-pecuniary benefits to interacting parties. FinTech covers areas such as banking, insurance, loans, personal finance, electronic payments, and wealth management of retail and corporate customers. The total global FinTech investment recorded was USD 164.1 billion in 2022, with 6,006 sales deals [35]. The global financial sector is expected to be worth USD 161.2 billion by 2027 [36].

With an estimated market opportunity of USD 1.3 trillion by 2025, the Indian FinTech ecosystem has emerged as a formidable global force [37]. Following the US and the UK, India is the third largest FinTech market. India's total FinTech funding in 2021 was USD 7.8 billion. India is considered advanced in FinTech/third party ecosystems, and it has an open banking readiness index of 6.1. The open banking readiness index provides a framework for banks to assess their open banking capabilities. It is defined based on

five dimensions—adoption of APIs, FinTech/third party ecosystem, state of data-based transformation, data monetisation, and state of innovation. It is measured on a scale of 0 to 10, with 0 being the lowest and 10 being the highest score [38]. The Indian FinTech market is expected to grow at a compound annual growth rate (CAGR) of 31% till 2025 [39,40]. With FinTech and traditional players working together, a greater potential is unlocked. Thus, OI is the key to growth for FinTechs and banks.

A total of 10,662 patents were awarded to 116 FinTech firms across the world in 2016. The average is around 92 patents per FinTech firm per year [34]. In 2018, financial technology accounted for nearly 4000 FinTech patent applications owned by some of the largest institutions in the technology and financial sectors such as Bank of America, Google, IBM, and Visa [41]. This level of patenting activity renders the financial technology industry a high innovation industry. FinTech OI is on the rise, as indicated in several research reports [37,42–46].

2.1.3. Open Innovation Intellectual Property Risk Factors

While multiple firms collaborate to produce a new product or service, the obvious question would be on who will own the IP created as a result of OI. Sound management of IP would require the identification of factors that lead to IP-related risks. Several factors influence the IP risk of a firm in an OI setting. While some firms rely on contractual agreements and formal methods for IP management in OI, which may lower the risks, other firms employ informal methods, which may substantially increase the risks [33,47]. The management of IP is largely trust-based in some cases, especially in start-ups and micro/small firms [48,49]. According to the available literature, thirteen distinct factors can influence the risks in IP management when an organisation engages in OI. These factors (Table 1) are: (i) IP management style—formal/informal [22,33,47]; (ii) contracts—non-compete/nondisclosure/other contractual agreements [22,33,47]; (iii) licensing model—exclusive/non-exclusive/ IP acquisition/IP transfer [10,15,17,18]; (iv) IP forms—patents/trademarks/copyright/trade secret [17,24,50–52]; (v) business/revenue model—revenue sharing/referral /others [17,25]; (vi) firm size (turn over) [53] ; (vii) stage of the firm—start-up to maturity [48]; (viii) collaborating stage [54] ; (ix) platform strategy [33,38]; (x) OI type—amongst firms/firms, universities/firms, and individuals (crowd sourcing) [26,33,55]; (xi) product types—business-to-business/business-to-consumer/business-to-government [49]; (xii) IP risk assessment and governance procedures [56]; and (xiii) cross-border OI [24]. While factors that can cause risk in IP management are identified, these factors are not being further utilised to assess the level of IP risk in collaborating organisations.

2.1.4. Research Gaps

Several researchers have studied the influence of IP management policies and organisational strategies on the performance of a firm while it engages in OI [7,13,17,25,33,57]. Sound IP management is crucial to protect the intellectual assets of organisations that are involved in OI. A key aspect of a sound IP management policy would be on how IP risk is identified and managed. Studies indicate that proactive risk management is beneficial for projects as it increases the predictability of outcomes [58–60]. Standardisation of risk identification and reporting are important [60], and a well developed risk awareness model ensures mitigation methods are identified and executed in a timely manner thereby reducing risk [59,61]. For effective risk management, the factors that contribute to IP risk in OI should be identified and assessed. However, there is no evidence for the use of IP risk assessment models in OI. There does not exist a 'one-size-fits-all' approach when dealing with IP risk management across firms. A tool that can simply and intuitively measure the various risk factors uniformly across various segments, such as start-ups, micro, small, medium, and large organisations is required [62,63]. In this context, the current study aims to define a new approach to IP risk assessment for firms that are engaged in OI in the software industry. As the FinTech industry is identified as the most innovative in the software industry, this study focuses on FinTechs in India.

2.2. Open Innovation Intellectual Property Risk Management

In the software industry, OI is a multidimensional and complex activity. A unified approach to IP risk assessment for various company segments such as start-ups, micro, small, medium, and large organisations is required to ensure sufficient protection of the intellectual assets of collaborating parties. The objectives of the study, the methodology, and the risk factors that contribute to IP risk, which can be configured to reduce the IP risk levels, are discussed, followed by an approach to OI IP risk assessment in the software industry.

2.2.1. Objectives

The first objective of this study is to define a model to assess the level of IP risk of organisations that engage in OI. To propose an OI IP risk assessment model, the key factors that can be configured to adjust the risk levels of an organisation are identified. Once these factors are identified, guidelines to assess these risk factors are defined so that all software firms follow the same guidelines for IP risk assessment. Further, a method to compute an open innovation intellectual property risk score (OIIPRS) based on these risk factors is proposed. The second objective of this study is to establish an open innovation intellectual property risk maturity model (OIIPRMM) that can depict the IP risk maturity of an organisation on the basis of varying levels of IP risk. The scope of this study is limited to the software industry and FinTechs in particular.

2.2.2. Methodology

The research work is carried out in four stages (Figure 1). The first stage of the research aims to identify factors that contribute to IP management risk in firms that are engaged in OI. From thirteen different factors identified from the existing literature, five factors that can be configured to reduce IP risk are determined in consultation with industry experts. The details of how to determine the five configurable factors from the thirteen different factors are discussed in subsequent sections. The second stage of this study focuses on developing a risk score that is based on these identified factors. For this, industry experts are consulted to perform a pairwise comparison of the factors by using the analytic hierarchy process online system (AHP-OS) [64]. The factors are compared pairwise for different company segments such as micro, small, medium, large, and start-ups [62,63,65], because the significance of these factors varies with the company segment. The resulting pairwise comparison matrix of the risk factors is fed into an AHP program that is written in the R software to compute the risk factor weighting for each company segment.

In the third stage, an online survey is employed to gather the risk factor scores of each identified risk factor from the organisations that are involved in OI. This study focuses on FinTechs in India that are engaged in OI. The OIIPRS of the organisation is then computed from the risk factor score that is provided by the organisation and the risk factor weighting that is established by using the AHP previously. The fourth stage of this study aims at establishing an open innovation intellectual property risk maturity model. This model depicts the IP risk maturity of organisations based on the computed OIIPRS on an IP risk continuum, with five levels of maturity, similar to the capability maturity model [66], the innovation maturity model [26,67,68], and the risk management maturity model [69–71]. The OIIPRMM helps organisations assess the level of IP risk and the extent of their maturity in IP risk management while engaging in OI.

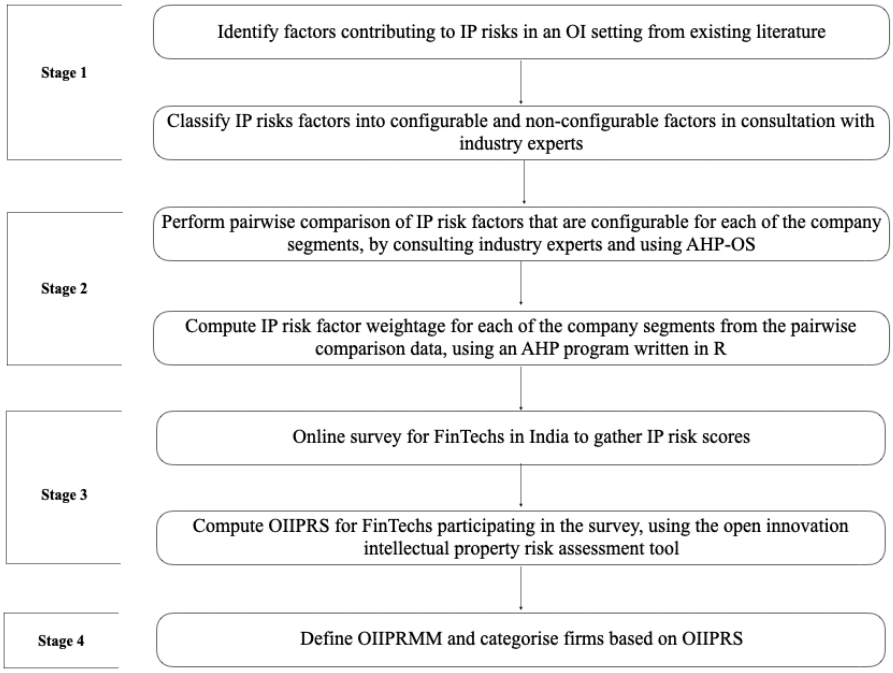

Figure 1. Methodology.

Ten IP management experts from the software industry are consulted to compute the intellectual property risk factor weights by using an analytic hierarchy process. Using random sampling, around 250 FinTechs that are headquartered in India or have a presence in India are surveyed to assess the OIIPRS. A list of FinTechs in India was identified based on several industry reports [37,72–74] and internet-based information. A senior executive from each of these identified firms was contacted to gather the targeted feedback by employing an online survey. Around 675 FinTechs were contacted from June 2022 to December 2022, out of which we received responses from 250 FinTechs. The chosen firms are sampled from different company segments such as micro, small, medium, and large organisations, and start-ups. The survey respondents include CXOs, product managers, and senior managers who are responsible for the innovation activities of the selected firms.

2.2.3. Configurable Intellectual Property Risk Factors

Several factors contribute to the risk that is related to IP in an OI setting. These factors can be broadly categorised as configurable and non-configurable factors, based on whether the factor can be configured to reduce the IP risk level of the organisation. Factors such as the size of the firm (turnover), the stage of the firm (start-up to mature organisations), the type of OI employed, the type of product developed, etc., cannot be altered; hence, they are non-configurable risk factors. The style of IP management (formal/informal), the contracts employed (nondisclosure agreements, IP ownership agreements, etc.), the licensing model (exclusive licensing, non-exclusive licensing, IP acquisition), IP risk assessment and the governance procedures followed, and whether the organisation is involved in cross-border open innovation can be configured to reduce the IP risk levels; hence, they are categorised as configurable risk factors.

The OI IP risk score and the maturity model are developed based on the configurable risk factors. The overall risk factors that are identified during the literature review are categorised as configurable and non-configurable in consultation with industry experts. Table 1 provides the list of IP risk factors, indicating whether they are configurable or non-configurable to vary the IP risk levels.

Table 1. Configurable/non-configurable IP risk factors.

Sl. No.	Factors	Configurable	Reason for Configurability
1	IP management style—formal/informal	Yes	Companies can implement formal IP management policies, thereby reducing IP risk
2	Contracts—non-compete/nondisclosure/ other contractual agreements	Yes	Sound legal agreements play a critical role in reducing IP risk
3	Licensing model—exclusive/non-exclusive/ IP acquisition/IP transfer	Yes	Appropriate licensing strategies can lower the IP risk
4	IP forms—patents/trademarks/copyright/ trade secret	No	While IP forms will influence the IP risk score, it is not a configurable option available to companies as each IP form is specific to the subject under consideration for IP protection
5	Business/revenue model—revenue sharing/referral/others	No	Revenue model agreed upon between the collaborating parties shall be grouped under licensing model and hence not required to be considered separately
6	Firm size (turn over)	No	Size of the firm cannot be adjusted to lower the IP risk
7	Stage of the firm—start-up to mature	No	The stage in which the firm is currently cannot be adjusted
8	Collaborating stage	No	The stage in which the firm opts for collaboration cannot be adjusted
9	Platform strategy	No	Not all participating firms will have a platform strategy
10	OI type—among firms, between firms and universities, between firms and individuals (crowd sourcing)	No	Not a configurable option for firms
11	Product types—business-to-business, business -to-customer, business-to-government	No	Not a configurable option for companies, and may not have a direct impact on IP
12	IP risk assessment and governance procedures	Yes	Risk assessment method, risk management procedures, and policy governance can influence IP risk
13	Cross-border OI	Yes	Depends on the firmś strategy and extra measures can be employed for IP protection and hence configurable

2.2.4. Open Innovation Intellectual Property Risk Assessment Model

Understanding the IP management risks when a firm engages in OI with another party will help the firm to devise appropriate strategies to lower the risk, which will protect their IP. In this context, a model to assess the risks that are associated with managing IP while engaging in OI is proposed. The OI intellectual property risk assessment model attempts to assess the risk levels of IP risk factors and compute a score to indicate the IP risk level of a firm. The risk score, termed as OIIPRS, indicates the risk level of organisations that are involved in OI, specifically in the context of managing IP that originates from the OI. A higher OIIPRS indicates that high risk is associated with IP management, and it signals to organisations to implement necessary controls to lower the risk levels.

The risk factors that are configurable are assigned weights by employing the AHP [75–83], which is one of the most commonly used multi-criteria decision-making (MCDM) methods for computing weights of factors involved in decision making. MCDM [81,84–87] is used when a decision involves taking multiple criteria into account in order to rank or choose between the alternatives. In situations where multiple factors contribute to an outcome, MCDM offers processes to assign weights to the criteria, signifying each criterion's contri-

bution to the outcome. AHP [82] is a widely used method of MCDM to assign weights to the factors involved, particularly for cases that use qualitative data [83]. The AHP model employs a pairwise comparison of the risk factors by industry experts to arrive at the weight of the risk factors. A three-step process is employed to compute the weights of the factors. First, a goal–criteria–sub-criteria hierarchy is established for the AHP analysis (Figure 2). The goal of the AHP analysis in this study is to compute the weight of IP risk factors in OI. The criteria include the five configurable IP risk factors that were identified in consultation with industry experts. The various values that are possible for each of the IP risk factors constitute the sub-criteria.

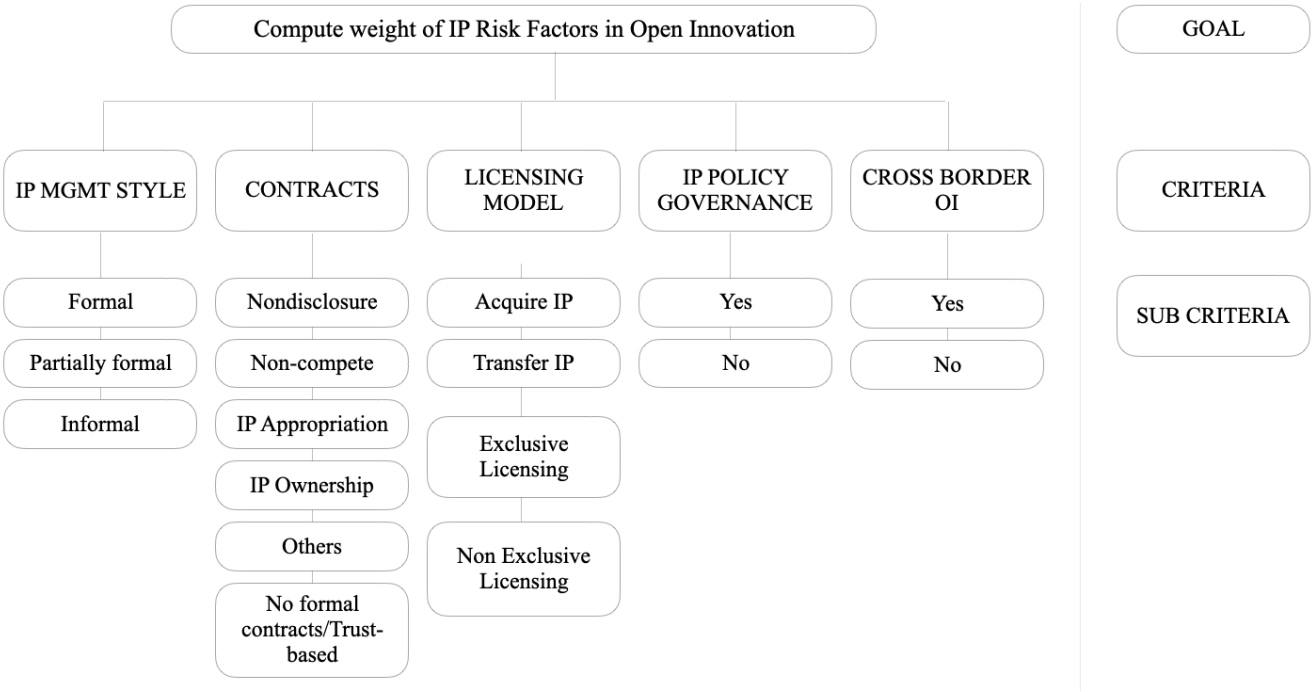

Figure 2. IP risk factors—AHP model.

Second, intellectual property industry experts are consulted to perform a pairwise comparison of the IP risk factors by using an AHP-OS [64], an AHP-based online system. In this stage, each IP risk factor is compared to provide the comparative importance of each factor against the other factors. Saaty's scale [75] is used to perform a pairwise comparison of the IP risk factors. In the AHP, the consistency of the expert judgements is assessed using a consistency ratio (CR). A pairwise comparison matrix is said to be consistent if the consistency ratio of the matrix is less than 10%. The AHP-OS gives a visual indicator of the comparisons that cause inconsistency, which makes it easier for the experts to review the comparisons and render them consistent. Industry experts perform the pairwise comparison of the IP risk factors for each of the company segments (micro, small, medium, large, and start-up). Third, the pairwise comparison is fed into a software program that is written in the R language to compute the weight of each of the configurable IP risk factors. The ahpsurvey package [88] provides a consistent methodology for researchers to reformat data and run AHP on data that are formatted using the survey entry mode.The risk factor weights that are computed by the R program for each company segment are depicted in Table 2.

An open innovation intellectual property risk assessment model that is based on a spreadsheet-based tool (Table 3) is provided to FinTechs to determine the risk factor score against each IP risk factor. On selecting the company segment, the risk factor weights, which are computed using the AHP analysis as applicable for the selected company segment, auto-populate in the tool. On selecting the appropriate response from the options provided against each assessment question, the risk factor score also auto-populates, based on the guidelines

provided (Table 4). The weighted risk score is computed by multiplying the risk factor weight and the risk factor score against each risk factor. The sum of the weighted risk scores yields the OIIPRS of the firm. A sample computation of the OIIPRS of a start-up is depicted in Figure 3.

Table 2. IP risk factor weights for various company segments.

Configurable IP Risk Factor	Micro	Small	Medium	Large	Start-up
IP management style	13.543	16.247	24.623	24.347	15.819
Contracts	37.49	34.789	29.343	29.625	40.281
Licensing model	23.442	23.68	18.369	15.097	20.872
IP policy/governance	15.326	14.76	16.77	17.567	12.886
Cross-border OI	10.2	10.525	10.895	13.365	10.142

For this research, the chosen FinTechs, which are headquartered in India or have a meaningful presence in India, were given the OI IP risk assessment tool. These firms were required to rate each of the questions corresponding to the configurable IP risk factors, based on the guidelines given in the tool. A total of 250 firms responded with their IP risk assessment. The computed total score, that is, the OIIPRS, was calculated automatically by the OI IP risk assessment tool. The OIIPRS can range from 100 to 500. If an organisation gave a rating of 1 to all the IP risk factors, the OIIPRS would be 100, which indicated a lower level of IP risk. If an organisation gave a rating of 5 to all the IP risk factors, the OIIPRS would be around 500, which indicated a higher level of IP risk.

Table 3. Open innovation intellectual property risk assessment model.

Open Innovation Intellectual Property Risk Assessment Model					
Instructions: *1. Select the company segment as applicable for your company from the dropdown values.* *2. On selecting the company segment, the risk factor weight will auto-populate.* *3. Select responses for each of the assessment questions from the options provided as dropdown values.* *4. On selecting the response, the risk factor score will auto-populate.* *5. The weighted risk score and the open innovation intellectual property risk score will be computed automatically.*					
	Select the Company Segment	Micro: Investment of less than Rs. 1 Cr and Turnover of less than Rs. 5 Cr Small: Investment between Rs. 1–10 Cr and Turnover of between Rs. 5–50 Cr Medium: Investment between Rs. 10–50 Cr and Turnover of between Rs. 50–200 Cr Large: Investment of greater than Rs. 50 Cr and Turnover of greater than Rs. 200 Cr Start-ups: Turnover of less than Rs. 25 Cr and years since establishment is less than 7 years			
Sl.No	**Assessment Question**	**Select response from the options provided**	**Risk factor weight**	**Risk factor score**	**Weighted risk score**
1	Please specify the method of IP management and protection followed in your organisation when it engages in open innovation	Yes, we have formal methods of IP management and IP protection (Score: 1) We have a basic framework for IP management and IP protection (Score: 3) No, we do not have formal methods of IP management and IP protection (Score: 5)			
2	Please specify the types of agreements employed to protect intellectual property while engaging in open innovation with external parties?	IP Ownership Agreement [Agreement on who owns the IP that originates from open innovation] (Score: 1) IP Appropriation Agreement [Agreement on how the revenue sharing is performed for the IP that originates from open innovation] (Score: 2) Non-Compete Agreement [Agreement not to compete with organisations with similar products/domain] (Score: 3) Nondisclosure Agreement [Agreement not to disclose to other parties the details of a product that originates from open innovation] (Score: 4) Other Contractual Terms [Any other contractual term that does not cover the above] (Score: 4) Mostly trust-based (Score: 5)			

Table 3. *Cont.*

Open Innovation Intellectual Property Risk Assessment Model			
3	What is your organisation's preferred model for licensing while engaging in open innovation?	Acquire IP—Our organisation owns the IP that originates from open innovation (Score: 1) Transfer IP: Our organisation transfers the IP to the collaborating firm (Score: 1) Exclusive Licensing: Our organisation enters into an exclusive licensing agreement with the collaborating firm, and will not share the work with anyone else (Score: 3) Non-Exclusive Licensing: Our organisation can licence the IP to other organisations as well (Score: 5)	
4	Does your organisation have a well-established IP risk assessment methodology and IP policy governance mechanism in place?	Yes, we have a formal IP policy governance and IP risk assessment mechanism (Score: 1) We have a very basic mechanism for IP policy governance and IP risk assessment (Score: 3) No, we do not have a formal IP policy governance and IP risk assessment mechanism (Score: 5)	
5	Does your organisation engage in cross-border open innovation ? [Meaning, do you collaborate with firms from other countries for open innovation]	No, we do not engage in open innovation with organisations in other countries (Score: 1) Yes, we engage in open innovation with organisations in other countries (Score: 5)	
Open Innovation Intellectual Property Risk Score (OIIPRS)			

Table 4. Guidelines to score IP risk factors.

IP Risk Factors and Options	Risk Level	Risk Factor Score
IP management style		
Formal methods of IP management and IP protection	Low	1
Have a basic framework for IP management and IP protection	Medium	3
Informal methods of IP management and IP protection	High	5
Contracts		
IP ownership agreement (agreement on who owns the IP originating from open innovation)	Low	1
IP appropriation agreement (agreement on how is the revenue shared for the IP originating from open innovation)	Low	2
Non-compete agreement (agreement not to compete with organisations with similar products/domain)	Medium	3
Nondisclosure agreement (not to disclose the details of product originating from open innovation to other parties)	High	4
Other contractual terms (any other contractual terms that do not cover the above)	High	4
No formal agreements (m)ostly trust-based)	High	5
Licensing Model		
Acquire IP—organisation owns the IP originating from open innovation	Low	1
Transfer IP—organisation transfers the IP to the collaborating firm	Low	1
Exclusive licensing—organisation enters into an exclusive license with the collaborating firm, and would not share the work with anyone else	Medium	3
Non-exclusive licensing—organisation can license the IP to other organisations as well	High	5
IP Policy Governance		
Formal IP policy governance and IP risk assessment mechanism	Low	1
Have a very basic mechanism for IP policy governance and IP risk assessment	Medium	3
No formal IP policy governance and IP risk assessment mechanism	High	5
Cross-border open innovation		
Do not engage in open innovation with organisations in other countries	Low	1
Engage in open innovation with organisations in other countries	High	5

			From AHP Program	By Firms	Computed
Open Innovation Intellectual Property Risk Assessment Model					
Select Company segment		Start-up - Turnover less than Rs. 25 Cr & year of establishment less than 7 years			
Sl No	**Assessment Question**	**Guideline**	**Risk Factor Weight**	**Risk factor Score**	**Weighted Score**
1	Please specify the method of IP management and protection followed in your organisation when it engages in open innovation?	Yes, we have formal methods of IP management and IP protection (Score: 1) We have a basic framework for IP management and IP protection (Score: 3) No, we do not have formal methods of IP management and IP protection (Score: 5)	15.819	2	31.638
2	Please specify the types of agreements employed to protect intellectual property while engaging in open innovation with engaging external parties ?	IP Ownership Agreement [Agreement on who owns the IP that originates from open innovation] (Score: 1) IP Appropriation Agreement [Agreement on how the revenue sharing is performed for the IP that originates from open innovation] (Score: 2) Non-Competing Agreement [Agreement not to compete with organisations with similar products/ domain] (Score: 3) Nondisclosure Agreement [Agreement not to disclose to other parties the details of a product that originates from open innovation] (Score: 4) Other Contractual Terms [Any other contractual term that does not cover the above]e (Score: 4) Mostly trust-based (Score: 5)	40.281	4	161.124
3	What is your organisation's preferred model for licensing while engaging in open innovation?	Acquire IP: Our organisation owns the IP that originates from open innovation (Score: 1) Transfer IP: Our organisation transfers the IP to the collaborating firm (Score: 1) Exclusive Licensing: Our organisation enters into an exclusive licence with the collaborating firm, and will not share the work with anyone else (Score: 3) Non-Exclusive Licensing: Our organisation can licence the IP to other organisations as well (Score: 5)	20.872	5	104.36
4	Does your organisation have a well-established IP-risk-assessment methodology and IP policy governance mechanism in place?	Yes, we have a formal IP policy governance and IP-risk-assessment mechanism (Score: 1) We have a very basic mechanism for IP policy governance and IP risk assessment (Score: 3) No, we do not have a formal IP policy governance and IP-risk-assessment mechanism (Score: 5)	12.886	3	38.658
5	Does your organisation engage in cross-border open innovation ? [Meaning, do you collaborate with firms from other countries for open innovation]	No, we do not engage in open innovation with organisations in other countries (Score: 1) Yes, we engage in open innovation with organisations in other countries (Score: 5)	10.142	5	50.71
Open Innovation Intellectual Property Risk Score (OIIPRS)					386.49

Figure 3. OIIPRS—sample for a start-up segment firm.

3. Results

Regular risk assessment of IP while engaging in OI enables organisations to protect their intellectual assets. The OI IP risk assessment model allows organisations to measure the level of IP risk that is involved in open innovation by computing the OIIPRS. Organisations can analyse the weighted score of each IP risk factor to identify areas of focus. Such an analysis would enable organisations to devise appropriate strategies to improve their overall IP protection mechanisms and reduce risk. Based on the OIIPRS, an OI IP risk maturity model is designed along the lines of the risk management maturity model, which enables organisations to assess their current maturity levels and propose targets for reduced risk levels.

3.1. Open Innovation Intellectual Property Risk Maturity Model (OIIPRMM)

The OI IP risk maturity model (Figure 4) depicts the risk maturity of organisations that are engaged in OI, and the characteristics of an organisation on an IP risk score continuum. The maturity model categorises firms into five segments, based on the OIIPRS. Such a maturity model helps firms to assess the level of IP risk and the extent of their maturity in their IP risk management while engaging in OI. It also equips them to devise appropriate strategies to reduce risk levels. Based on the OIIPRS, that ranges from 100 to 500, five levels of IP risk maturity are defined: (i) level 1, initial; (ii) level 2, developing; (iii) level 3, established; (iv) level 4, advanced; and (v) level 5, optimised.

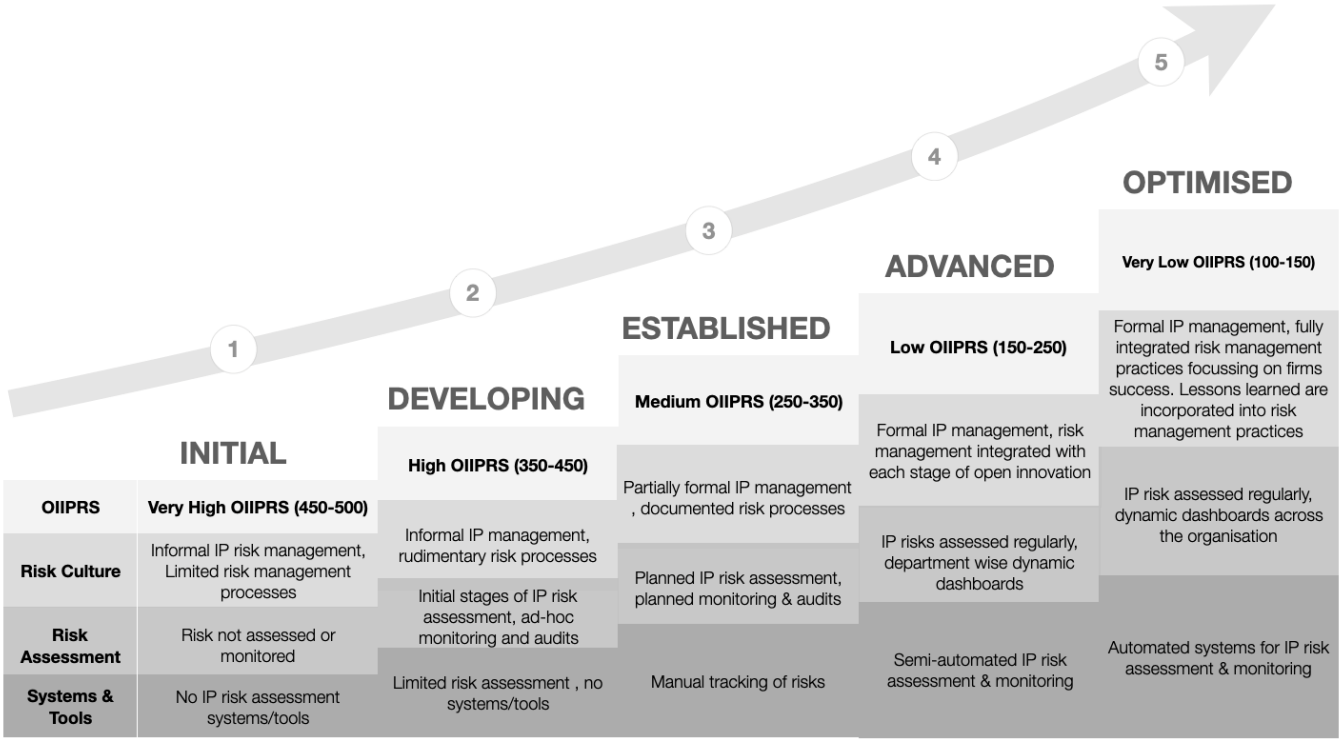

Figure 4. Open innovation intellectual property risk maturity model (OIIPRMM).

Initial: Firms that have a very high OIIPRS, ranging from 450 to 500, fall under the 'initial' category. Such firms have informal IP risk management practices and IP risk are not assessed or monitored. They do not possess IP risk assessment system/tools and have no governance mechanisms for IP risk management.

Developing: Firms that have a high OIIPRS, ranging from 350 to 450, are grouped under the category, 'developing'. They have informal IP management practices and rudimentary risk assessment processes. Although they have devised monitoring mechanisms, these are not regular. They have no IP risk assessment tools/systems.

Established: Firms that have a medium OIIPRS, ranging from 250 to 350, fall under this category. They have partially formal IP management. They have documented risk management processes and planned IP risk assessments that are performed periodically. They follow manual processes for risk monitoring and tracking.

Advanced: Firms that have a low OIIPRS, ranging from 150 to 250, fall under this category. They have formal IP management and risk management processes integrated with each stage of OI. The IP risk is assessed regularly, and dynamic dashboards that indicate the risk and the associated information are made available department-wise in the organisation. Such firms also have semi-automated IP risk assessment and monitoring procedures.

Optimised: Firms that have a very low OIIPRS, ranging from 100 to 150, fall into the 'optimised' category. They have formal IP management and risk management practices that are focused on the firm's repeated success. Lessons that are learnt from previous OI engagements are continuously incorporated into risk management processes and procedures. Their IP risk is assessed regularly, and dynamic dashboards that indicate the risk and the associated information at the organisational level are made available. Such firms also have established automated systems for IP risk assessment and monitoring and depend less on individuals.

3.2. Open Innovation Intellectual Property Risk Assessment Results

Of the 250 FinTechs that took part in the OI intellectual property risk assessment study, 180 FinTechs practised OI, while 70 FinTechs did not engage in OI. Of the 180 FinTechs carrying out OI, 32% were large firms, 27% belonged to medium-sized companies, 16%

were small companies, 9% were micro-enterprises, and 16% were start-ups. The lowest OIIPRS score was 100, and the highest was 471. The distribution of the OIIPRS across the various company segments is captured in Table 5 and Figure 5. The corresponding box plot is depicted in Figure 6. Though the large firms show a comparatively higher range for the OIIPRS, the majority of the firms have risk scores below 350, indicating that they have scope to reduce their risk score levels.

Table 5. OIIPRS distribution.

Company Segment	Minimum OIIPRS	Maximum OIIPRS	Average OIIPRS	Range
Large	100.001	421.686	217.656	321.685
Medium	143.58	470.657	316.376	327.077
Small	159.041	465.216	340.041	306.175
Micro	293.767	462.515	382.406	168.748
Start-ups	140.568	428.081	319.932	287.513

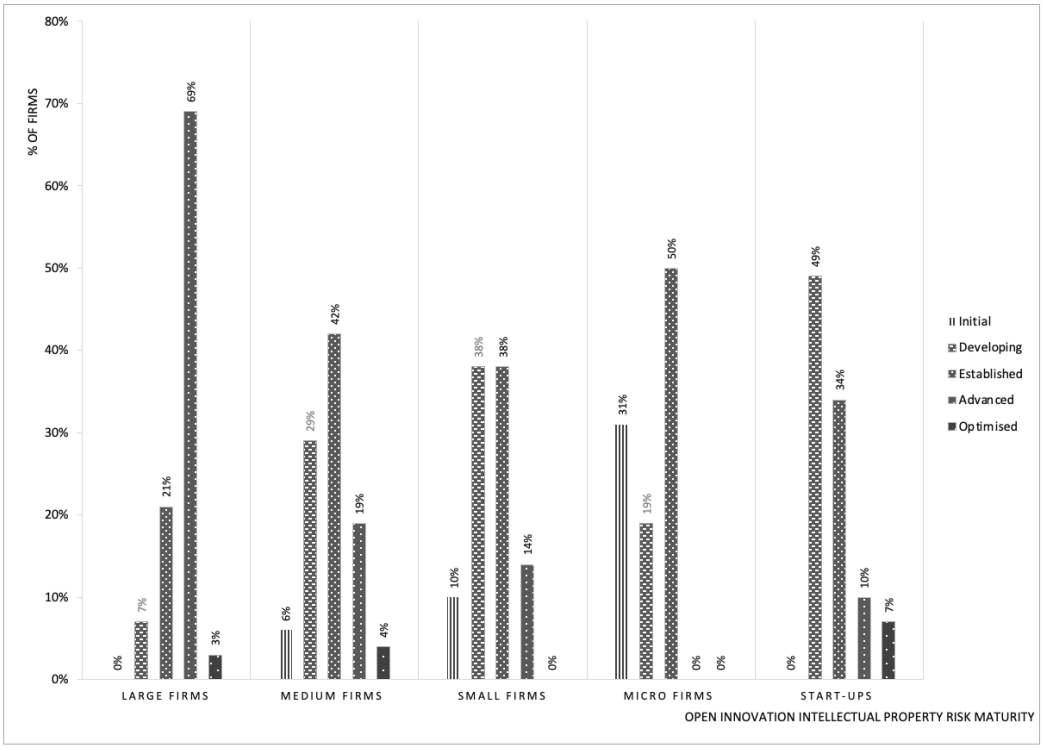

Figure 5. Open innovation intellectual property risk score—absolute comparison.

In the aspect of maturity, 69% of large firms are in the advanced stage of IP risk maturity. No large firms are in the initial category. This observation coincides with the general practice of most large firms of having well-defined processes for IP management and, thus, a lower OIIPRS. However, only 3% of large firms are in the optimised category, possibly owing to the difficulties in standardising practices across departments. Interestingly, none of the start-ups are in the initial category, which is contrary to the belief that start-ups follow ad hoc processes. A significant number of medium, small, and micro segment firms, and start-ups belonged to the developing or established category with a medium to high OIIPRS indicating that there is larger scope for these firms to develop better IP management strategies and reduce IP risk levels. Very few firms were in the optimised category across all company segments, confirming that more focused efforts are required in reducing IP risk when firms engage in OI.

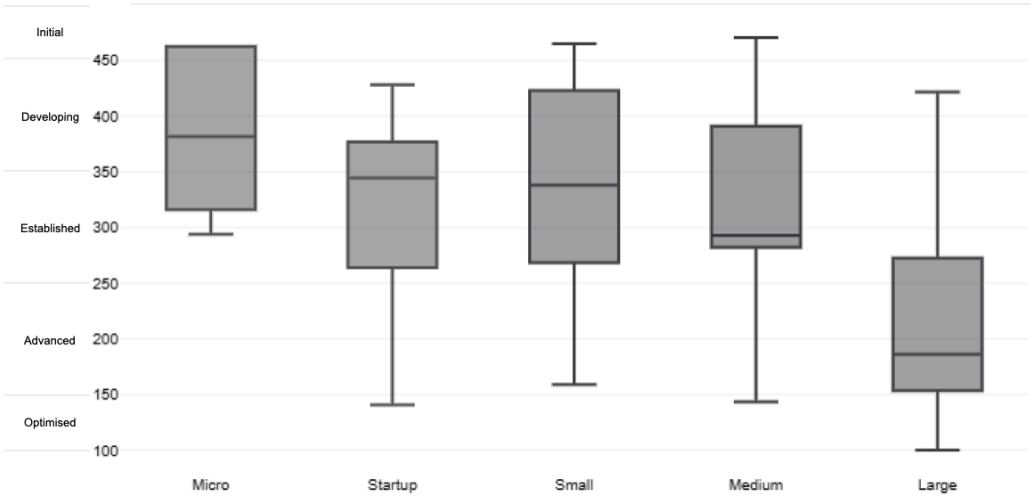

Figure 6. Open innovation intellectual property risk score—box plot.

4. Conclusions

This research work contributes to the project management and open innovation literature. The open innovation intellectual property risk assessment model proposed in this article contributes to the risk management practices in project management. The open innovation intellectual property risk maturity model provides an opportunity for project managers to review the IP risk and devise appropriate strategies to reduce the IP risk. This article also significantly contributes to the IP management literature that is related to OI. The open innovation intellectual property risk assessment model presents a unified approach to the quantitative measurement of the level of IP risk in organisations that engage in OI. The simple, user-friendly, spreadsheet-based assessment renders the independent administering of the assessment by organisations effortless. The analytic hierarchy process, which is a robust multi-criteria decision-making method that is used to compute the IP risk factor weights, establishes the integrity of the assessment model. The assessment procedure is standardised by establishing guidelines, which renders the OIIPRS comparable across organisations.

The open innovation intellectual property risk maturity model categorises firms into five levels of IP risk maturity based on the OIIPRS. The IP risk maturity of organisations can be assessed by the OIIPRMM when it is used as a benchmarking tool. Consulting organisations can employ the OIIPRMM to assess the IP risk maturity of organisations and compare the maturity levels of organisations that operate in a given functional domain. Such assessments, which are made by consulting organisations, enable the organisations that engage in OI to compare their competitive positions in terms of IP risk management practices. In addition, it allows organisations to strengthen their processes to ensure risk reduction for innovation projects' success and in turn better IP protection. The IP polices of an organisation plays a key role in the organisation's performance and enable sustained growth, and IP risk reduction measures form a crucial part of IP policies. Additionally, to enable investors to assess investment opportunities, the OIIPRS could serve as one of the parameters.

In India, a significant number of surveyed large and medium FinTechs have well-established IP management procedures to protect IP that originates from OI. Few of the Indian FinTech start-ups seem to have IP management strategies in place as well. While this study has focused on FinTechs in India, the model that is proposed in this article can apply to software firms worldwide. The risk factors and corresponding weights computed with AHP will apply as-is for software firms worldwide. However, additional research is required to study the applicability of the IP risk factors that are identified for the software industry to non-software industries.

The current research scope is limited to considering factors that are configurable by firms to attain lower levels of IP risk while engaging in OI. The influence of the eight identified non-configurable factors on the OIIPRS needs further analysis. Both configurable and non-configurable factors can be included in the AHP model to perform pairwise comparison to compute the weights of each factor. Thus, an enhanced version of the open innovation intellectual property risk assessment model with both configurable and non-configurable factors can be developed in future.

As the software industry is fast evolving and product life cycles are becoming shorter, the factors and weights used in the model need reassessment on a yearly basis. Firms engaging in OI are also recommended to assess the IP risk on a monthly basis to formulate appropriate mechanisms to lower IP risk. The available literature on OI is limited to assessing firms' performance. There is no research around measuring IP risk involved in OI. Thus, comparison of the scores generated by the proposed model in this research with another model is not viable. When researchers develop other IP risk assessment models for OI, a comparison of results produced by such models and the proposed model in this research can be performed to assess the robustness of the model.

Further research is required to assess how the identified IP risk factors can be configured to devise contextual IP management policies in order to reduce IP risk levels and move up the risk maturity continuum for the various company segments such as micro, small, medium, and large organisations, and start-ups. The impact of the involvement of other parties such as universities and individuals, and the use of open-source software in OI can also be investigated in further research.

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Abbreviations

The following abbreviations are used in this manuscript:

AHP	Analytic hierarchy process
Cr	Crore, equivalent to 10 million
CAGR	Compound annual growth rate
IBM	International Business Machines
IP	Intellectual property
MCDM	Multi-criteria decision-making
OI	Open innovation
OIIPRS	Open innovation intellectual property risk score
OIIPRMM	Open innovation intellectual property risk management model
Rs	Indian Rupees
USD	United States Dollar

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