Successfully Operating Patent Digital Platforms (PDPs) in China: A Configurational Perspective

Kaitong Liang[a,d], Lei Ma[b,d] , Zheng Liu[c,d] and Chaonan Yi[a,d]

[a] School of Intellectual Property, Nanjing University of Science and Technology, Nanjing, P.R. China; [b] School of Public Affairs, Nanjing University of Science and Technology, Nanjing, P.R. China; [c] Cardiff School of Management, Cardiff Metropolitan University, Wales, UK; [d] Centre for Innovation and Development, Nanjing University of Science and Technology, Nanjing, P.R. China.

ABSTRACT: The increasing value of patents for innovation and the permeability of digital technologies have triggered Patent Digital Platforms (PDPs) as a new business model of patent intermediaries. Whilst current literature mainly focuses upon PDPs within a developed country, China shows unique features with a relatively unmatured patent market. This paper aims to explore conditional configurations that lead to the operational success of PDPs throughout China. The results indicate two configurational paths: 'firm size driven' and 'digital infrastructure and knowledge assets driven'. Furthermore, environmental factors are peripheral conditions yet important. Our findings have enriched the understanding of patent intermediaries in digital age and sheds light on PDP theory and practice.

KEYWORDS

Patent Digital Platforms (PDPs); China; Configuration Theory; Digital Infrastructure

CONTACT Lei Ma, maryma208@sina.com

1. Introduction

With the rapid pace of digitalization, the patent services sector has been witnessed to change since the beginning of the 21st century. Defined as ‘commercial organizations that promote patent transactions and support customer innovation activities’, patent intermediaries are traditionally categorized as Patent Attorney and Technology Transfer Office (TTO) (Alvarado,2013; Benassi & Di Minin,2009). However, these business models are faced with the great challenge of realizing the value of a patent within the digital world; the increasing cost of searching and matching buyers and sellers and the restraints of evaluating patent merits are two examples (Hagiu & Yoffie,2013). Digital platforms that combine technical elements and associated organizational processes and standards have emerged across patent intermediaries (Gawer,2021; Nambisan et al.,2019) and these can be referred to as ‘Patent Digital Platforms (PDPs)’ (Liang et.al.,2022). Indeed, enabled by both the ‘Internet of Everything (IoE)’ and digital technologies, the PDP is a system that aggregates multiple participants through its network effect in order to reduce risk and costs during patent transactions. The PDP endeavors to support customers with feasible solutions, and aims to promote the value of patents (Ma et al.,2021). For example, Questel is a world-class intellectual property (IP) solution provider that has gathered various participants, such as the business lead in patent translation, ‘MultiLing’, which serves global Multi-National Enterprises (MNEs), including IBM, Huawei and Pfizer, through the utilization of its database ‘Oribit’ (Agrawal et al.,2016).

Some scholarly observers have investigated this phenomenon by focusing their attention on patent markets. No matter whether the patent is considered a ‘patent broker’ (Benassi & Di Minin,2009), ‘solver brokerage’ (Feller et al.,2012) or ‘online marketplace’ (Alvarado,2013), the functions of the PDP can mainly be divided into two fundamental aspects: one aspect is the promotion of patent transactions and the other is to provide feasible solutions to innovators. To fulfill these functions, PDPs can provide services such as patent analysis, patents value evaluation, or knowledge training (Caviggioli & Ughetto,2013; Petrusson,2010; Agrawal et al.,2016; Hagiu & Yoffie,2013). However, extant literatures have not shed light on how PDPs can perform such functions. In fact, the operating of PDP is a complex system that influenced by various factors. Some of these factors, such as patent systems protection, may be a priority in that PDPs can perform their functions with ease (Thumm,2018). Nevertheless, less attention has been paid to putting these factors together and providing a holistic view of PDP's operation. Hence, exploring the influential paths to the successful operation of PDPs can offer further insights into their role within the patent market.

The discussion around PDPs tends to mainly focus upon PDPs within the USA or Europe, countries whose patent markets are relatively mature (Wang,2010). Meanwhile, there are other countries where patent markets are showing growth, thus demonstrating new features of the PDP that have been previously underexplored. For example, China's intellectual property income as a percentage of total trade is ranked globally at a position of only 36[1], yet, some PDPs, such as Sixlens and Baiten, have indeed still achieved success throughout China, matching millions of patent transactions, serving millions of customers, making great contributions to facilitate technology transfer and enhancing the innovation capabilities of local innovators[2] (Liang et.al.,2022). Therefore, the success of PDP operations in China indeed shows that success can be achieved for other countries whose patent markets are yet unmatured (Yusuf,2008; Villani et al.,2016). Accordingly, this paper aims to answer the following question:

What kind of conditional configurations lead to PDPs' successful operation in China?

To address this causal complexity issue, configuration theory is applied throughout this paper. Specifically, we conclude with the technological, organizational and environmental factors that influence PDP operations in China, and that can be found in the literature review, and we develop a conceptual model. We then study the complex, nonlinear relationships among these factors by applying the comprehensive use of Data Envelopment Analysis (DEA) and Qualitative Comparative Analysis (QCA) with samples from China. The paths that are used to achieve PDPs' success in China are then summarized.

The marginal contributions of our paper lie within the following three aspects. Firstly, a conceptual model of PDP operations has been established based on configuration theory, adding a few contributions in order to provide a holistic view and understanding of a new business model of patent intermediaries during this digital age. Secondly, the path to successful PDP implementation have been identified, which furthers the understanding for its role on patent markets, and finally, this paper explores PDPs in the context of China, which has enriched the scope of the PDP in countries where patent markets are still in the growth period.

This paper proceeds as follows: **Section 2** presents the literature review, which relates to both patents and PDPs, thus a conceptual model is thereby developed. **Section 3** describes the methods, samples, variables and data sources that are used within this paper. **Section 4** clarifies and discusses the results that were found during the undertaking of this paper. **Section 5** presents the conclusion.

2. Literature Review and Conceptual Model

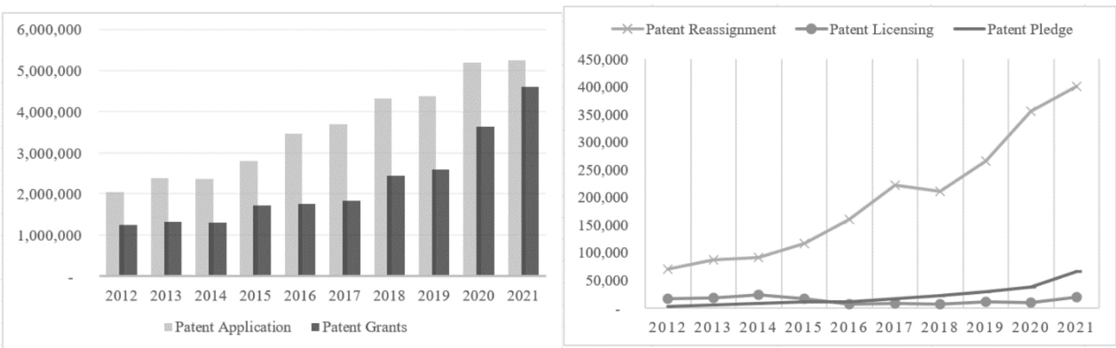
2.1. The Increasing Value of Patents for Innovation

Patents - commonly understood as a legal right granted by a governmental office that is responsible for intellectual property affairs - are increasing the value for innovators, and this in turn has attracted scholarly attention that seeks to explore it from different perspectives (Petruzzelli et.al.,2015). As a legal right, patents can prevent the infringement of products or services through providing temporary monopoly rents to patent owners (Baldwin & Henkel.,2015). It has been considered as a powerful weapon within the remit of business litigations so far (Arora & Ceccagnoli.,2006). As a knowledge asset, patents can create profits for innovators through commercialization, particularly after the patent monetization strategy that has been implemented by IBM (Boudreau et.al.,2022). This is a type of technological resource that flows across innovators, industries, regions, and nations (Kwon,2020). As innovation data, patents can provide information about the technological development trends and innovation dynamics (Ardito et.al.,2014,2018). The extensiveness of patent data can support innovators so that that they may decide a more effective strategy related to R&D, marketing or human resources (Evangelista et.al.,2020).

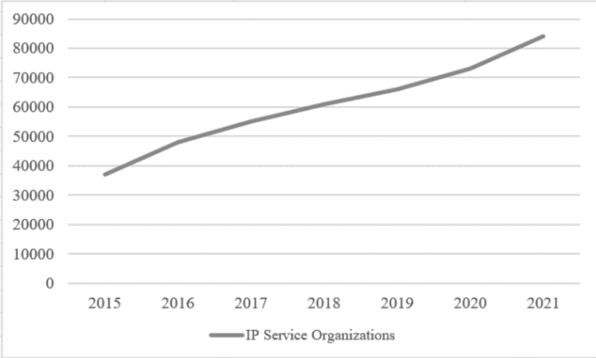
However, the increasing value of patents for innovation underlies the enhancing difficulty to realize them. For instance, the growth of patent thickets creates strong friction in innovation due to a pronounced potential for patent right holders, resulting in the substantial bargaining costs (Fischer & Ringler,2015). The tragedy of commons about overlapping patent rights has triggered market demands for a more in-depth knowledge, or professional capabilities in order to realize the value of a patent (Lin et.al.,2020). In order to bridge the existing gap between knowledge and professional capabilities for innovators, patent intermediaries have emerged (Liang et.al.,2022). Digital platforms can be considered as a new business model that further enhances the patent intermediary's capability to gather fragmented knowledge and provide professional services throughout the patent market, which then affords new ways of creating and delivering patent value to customers (Nambisan et al., 2019). Hence, PDPs are considered as a business model innovation of a patent intermediary. Nevertheless, little is known about how some of these platforms can operate successfully - especially in countries where patent markets are still in growth - resulting in a deficiency to formulate a comprehensive picture of patent intermediaries (Yusuf,2008; Villani et al., 2016).

2.2. Factors for Operating PDPs in China

In order to seek and gain answers to our research question, a brief introduction and understanding of the Chinese patent market was firstly needed. In 2013, China National Intellectual Property Administration (CNIPA) issued the 'Notice on Organizing the Application of National Patent Operation Pilot Enterprises', and this is when patent commercialization was first conceptualized within Chinese policies. Since then, patent application and patent grants have been prolific. Patent commercialization, including patent reassignment, patent licensing and patent pledge, have increased substantially in number, especially after the construction of the Sino Intellectual Property Operation Platform (SIPOP) in 2015. The year of 2015 can be considered as significant for PDPs in China due to an explosive growth of IP service organizations. This can be seen below in **Figure 1**.



(a) (b)



(c)

FIGURE 1 The Patent Market in China

Sources: CNIPA. Evaluation Report on China's Intellectual Property Development.

The contextual characteristics of the Chinese patents market can be integrated as follows: firstly, the development of patent market is mainly driven by IP policies, which means that the government is an indispensable actor. Secondly, the value of patents still needs to be realized; for example, compared to other developed countries, the numbers of patent transactions in China are disproportionate to the number of patent applications. Thirdly, the development of the PDP is synchronous with the development of digital economy; in 2015, the State Council issued a policy "'Guiding Opinions on Actively Promoting the Action of 'Internet Plus'", which has emphasized the integration of the internet with various social and industrial fields, thus creating a favorable environment that enables the growth of PDPs.

Under such circumstances, the operation of PDPs in China is a complex system that is influenced by diverse factors (Ma et al.,2021). Some of these factors have been discussed in prior studies that have investigated patent intermediaries, such as location (Reiffenstein,2009), patent systems (Benassi & Di Minin,2009; Thumm,2018), patent intensity (Caviggioli & Ughetto,2016), market demands for commercializing patents (Feller et al.,2012), knowledge base (Monk,2009), reputation (Wang,2010) or size (Hagiu & Yoffie,2013) of patent intermediaries, and the unique effect of ICT or the internet (Petrusson,2010). Due to the causal complexity of PDP operations, it is unrealistic to take all factors into consideration. Therefore, according to prior studies and the contextual characteristics of the Chinese patent markets, this paper scopes 8 antecedent conditions by taking the issue of 'limited diversity' into account: the definition of 'limited diversity' is as follows: when too many factors cause the functional limitations of a system (Park & Mithas,2020) (as shown in **Figure 2**). The 8 influencing factors have been categorized into three contexts:

1) Technological

2) Organizational

3) Environmental

Technological context describes factors that adopt digital technologies for PDPs, including the local construction of digital infrastructures and the local size of digital industries (Tilson et.al.,2010). Organizational context describes the noteworthy resources that a PDP has, including firm size, knowledge assets and reputation (Appio et.al.,2021). Environmental context describes the indirect factors required for PDP operations, including the patents intensity, patent market-demand and patents' system protection (Sun et al.,2015). The reasons for choosing these factors will be discussed in the following section.

2.2.1. Technological Context for Operating PDPs

Previous studies have discussed the effect that ICT and the internet have upon different types of patent intermediaries and these studies have found that the use of ICT can potentially expand the scale of patent markets by reducing knowledge ambiguity (Feller et al., 2012). It can also capture the precise value of patents by listing and identifying them (Dushnitsky & Klueter, 2017). The development of the internet has led to the reduction of patent transaction costs; use of the internet overcomes the barrier of geographical boundaries and, by utilizing the internet resourcefully, a large number of participants can be gathered (Clarke, 2016). However, since PDPs can be likened to an ecosystem that gathers various resources and participants to realize the value of patents, the convergence and generative capability of digital technologies may become more important and necessary in order to operate the PDP (Gawer, 2021; Jovanovic, 2021).

The use of digital technologies varies across the location of PDPs (Reiffenstein, 2009). In other words, technological factors may play different roles depending upon which region they are found. Hence, two factors have been employed: one is the local construction of digital infrastructures and the other is the local size of digital industries.

Digital infrastructure refers to 'the basic information technologies and organizational structures, along with the related services and facilities necessary for an enterprise or industry to function' (Tilson et.al., 2010). The local construction of digital infrastructures can be thought of as the engine for operating PDPs (Miric et al., 2019).

For example, Sixlens, a PDP that operates in Hangzhou city, China, has selected ‘Ocean Base’, which is a cloud computing platform developed by ANT Group Co., Ltd., in order to enhance its capacity for processing massive patent data. The construction of digital infrastructures has provided a technical base for PDPs to iterate its database and upgrade patent services. Therefore, the local construction of digital infrastructures is important for operating PDPs.

The term ‘digital industry’ encompasses software, telecommunications and other industries that are driven by digital technology (Teece, 2018). The agglomeration of the digital industry can gather skills that relates to digital technologies, promotes knowledge transfer between digital industries and other industries and accelerates regional innovation of digital technology (Zaki, 2019). This has aided PDPs within varying regions to access digital technologies, and helped them to adopt the strong network effects and data advantages of the digital industry (Beltagui et.al., 2020). Furthermore, except for patent data, the digital industry can generate massive data in other fields such as technology, business and talent; it can also provide opportunities for PDPs to develop new service concepts (Benassi & Di Minin, 2009). For example, SIPOP, a public service PDP that has been constructed by a state-owned enterprise called ‘Huazhi Zhongchuang (Beijing) Investment Management Co., Ltd.’, has gathered policy, industry and service data from China Mobile Communications Group Co., Ltd and other companies belonging to digital industry. Hence, the local size of digital industries needs to be taken into consideration.

2.2.2. Organizational Context for Operating PDPs

Since most of the PDPs in China are SMEs, resources need to be used carefully and cost-effectively in order that success can be achieved. According to the resource-based view, business resources are closely related to their sustained competitive advantage (Barney, 1991). For PDP operations, this paper proposes that these important resources should include the business size, knowledge assets and reputation, based on prior studies on patent intermediaries (Monk, 2009; Gambardella et.al., 2007).

It’s worth noting that the vast existing research has explored the effects of a company’s size on its innovation performance (Antonio et.al., 2012). The success of Yet2.com and Questel have provided us with insights that suggest that the size of the firm, a manifestation of its network effect, can help innovators to reduce transaction costs for both sides of the patent market, as well as the uncertainty in patent value evaluation (Hagiu & Yoffie, 2013). Theoretically, the larger the size of a firm, the better the organization's capabilities and resource conditions (Calof,1994). Therefore, the size of a company's PDP needs to be looked at as a prominent factor that will enable successful operation.

Knowledge assets are a combination of cognitive processes, context understanding, and experiences, and they mainly refer to intelligent resources that are constantly accumulated within the business, including patent, trademark, and copyright in general (Li & Tsai, 2009). The ownership of knowledge assets might be useful so as to attract finance and generate profitability (Kafouros et.al., 2021). The knowledge assets for PDPs can be considered as the result of combining legal and technical expertise, engineers, product developers and patent lawyers, and integrating fragmented knowledge (Kramer et al., 2011). Hence, knowledge assets are a prominent factor for PDP operations.

The findings of previous studies have suggested that reputation development is indispensable for the commercialization of knowledge (Lichtenthaler & Ernst, 2007; Feller et al., 2012). Reputation has multiple functions with regards to PDP operations (Chu, 2013). Firstly, it can build trust among its participants, including customers, government, and universities, and form a long term and stable cooperation. Secondly, reputation can aid PDPs in overcoming the problems that are encountered within the patent markets, such as the increasing patent transaction costs. Finally, as PDPs and their stakeholders can gain reputation in different ways, the profit from innovation will be increased. The reputation of a PDP may make a huge impact on its operation.

2.2.3. Environmental Context for Operating PDP

In China, the emergences of PDPs are mainly driven by IP policies, which have demonstrated that environmental factors are indispensable for PDP operations. According to previous literature, environmental factors for operating patent intermediaries are closely related to the intensity of the patent, the patent's market demands and patent system protection (Caviggioli & Ughetto, 2016; Petrusson, 2010; Benassi & Di Minin, 2009). Furthermore, the level of patent intensity, patent market demands and patent system protection is heterogeneous across regions, which means environmental factors are explored in terms of regional perspective.

Patent intensity refers to the amount of patents found in production activities (Sun et al., 2015). It is clear that only in patent markets with a high patent intensity can PDPs play roles pertinent to the integration of fragmented patents and realize their value (Benassi & Di Minin, 2009). Furthermore, it requires a massive amount of data for PDPs in order to capture innovation dynamics, technological trends and any other valuable information about firms or innovators (Agrawal et al., 2016). Thus, this paper considers patent intensity as one of the dimensions of a complex environment that has an effect upon PDP operations.

Patent market demands are significant for PDP operations also. Diversified needs to convert patents into money have emerged rapidly within the patents market, since the increasing value of patents for innovation (Caviggioli & Ughetto, 2013). The patent thicket phenomenon has triggered the deficiency of innovators to commercialize their patents, which creates business opportunities for PDPs (Fischer & Ringler, 2015). Satisfying the demands of the patent market is the main functions of PDPs.

The relationship between patent systems and patent intermediaries has been widely discussed by scholars (Reiffenstein, 2009). Some scholars argue that a patent system can provide patent intermediaries with a tool of self-discipline that will both ensure the establishment of business and open access to new technologies (Petrusson, 2010). The level of patent systems' protection can have a direct impact on the activation of the patent market (Dushnitsky & Klueter, 2017). Under the protection of a patent system, PDPs can increase the productivity within both a business and the patent markets.

2.3. Conceptual Model

Within this paper 8 factors have been scoped that influence PDP operations, yet in the Chinese patent market, each of these factors would inter-dependently, rather than independently, have an effect upon the result of PDP operations. Thus, configuration theory is selected so as to investigate the research question. Configuration theory originates from systems theory, which states that the isolated analysis of components, based on reductionism, can only partially assume conclusion (Meyer et.al., 1993). It considers that the result of an event is caused by the complexity of various factors, represented by the formation of several equivalent configurations obtained through Boolean logic (Miller, 2017). Additionally, factors that are causally related in one configuration may be unrelated or inversely related in other configurations (Han & Zhang, 2022). Taking PDPs, for instance; the success of some successful PDP operations may be owed mainly to the construction of local digital infrastructures and accumulation of knowledge assets, yet the success of others may be owed for the most part to both the size of the business and its reputation. Furthermore, some configurations may lead to unsuccessful PDP operations, but this is not the focus of this paper. Configuration theory can offer a holistic view about the paths that need to be taken to achieve successful implementation of PDPs. Therefore, a conceptual model is proposed (**Figure 2 below**), which highlights the important factors affecting PDP operations, yet their configurational paths to successful PDP implementation in China are unrevealed by prior studies.

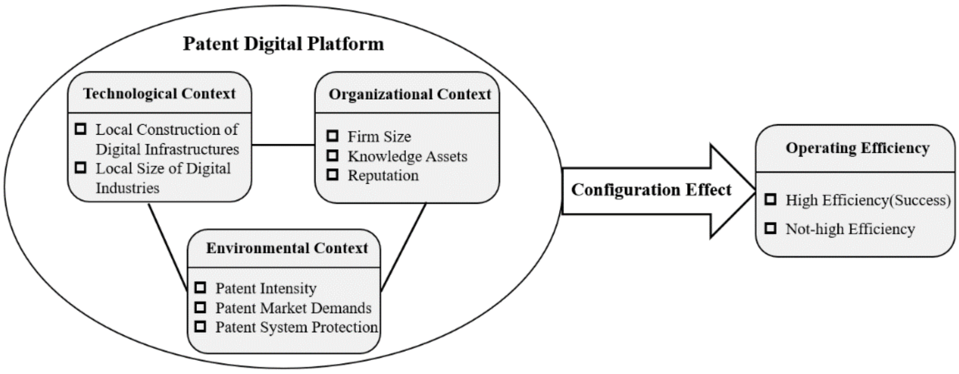


FIGURE 2 Conceptual Model

Sources: The authors.

Within this paper, we suppose successful usage of PDPs are operated with high efficiency, because configuration theory emphasizes the logic of abduction, and the research objective should be in a stable result, as the premise of finding its antecedents.

3. Research Methodology

Our research question is: *What kind of conditional configurations lead to the successful operation of PDPs in China?* To answer this question within this paper, a combination technique of Data Envelopment Analysis (DEA) and Qualitative Comparative Analysis (QCA) is applied in order to prove the validity of the conceptual model. The comprehensive use of DEA and QCA to solve causal complexity questions has been a trend throughout management research in recent years, since DEA is suitable for evaluating the operating efficiency of a research objective, providing a method to measure the result of an event (Li et.al., 2021; Qiang et.al.,2021). Moreover, QCA is a neo-analytical method of configuration theory that can figure out causal complexity questions, both theoretically and empirically, by undertaking analysis of the determinants affecting operating efficiency (Misangyi & Acharya, 2014). Therefore, in this paper, DEA is used to measure the operating efficiency of Chinese PDPs, and QCA is used to investigate the paths taken to ensure the success of PDPs in China.

3.1. Analytical Method

3.1.1. Data Envelopment Analysis (DEA)

As stated by Charnes et.al (1978), Data Envelopment Analysis (DEA) is a method used to evaluate the efficiency of a sample of Decision-Making Units (DMUs). Suppose there exists a sample of the DMUs ($\mathrm{DMU_j}$) and each sample contains several inputs and outputs. To evaluate $\mathrm{DMU_j}$, we need to regard them as a production process with an overall input and output and weight each input $v_i(\mathrm{i} = 1,2,\ldots,\mathrm{m})$ and output $u_r(r = 1,2,\ldots,s)$ appropriately. The efficiency of a DMU (θ_j) can be expressed as:

$$\theta_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}},\ (j = 1,2,\cdots n) \tag{1}$$

To discuss whether a DMU is relatively 'optimal' in $\mathrm{DMU_j}$, it can be assumed that there exists a $\mathrm{DMU_o}$ in $\mathrm{DMU_j}$ as the most optimal one and its efficiency is θ_o, which can be expressed as:

$$\begin{aligned} &\theta_o = Maximize \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \\ &subject\ to \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1, j = 1,2,\cdots,n, \\ &u_r \ge 0, v_i \ge 0,\ \forall r, i. \end{aligned} \tag{2}$$

The efficiency score θ_o is comprised between 0 and 1. The value 1 characterizes the efficient DMU; the lower the score, the more inefficient is the DMU. The success of PDPs in this paper means the DEA value of its operating efficiency reaches 1.

3.1.2. Qualitative Comparative Analysis (QCA)

QCA, first proposed by Ragin in 1987, is an analytical method that focuses upon exploring the causes of the concurrences of multiple conditions in social phenomena. Through analyzing and comparing each case, the set relationship between the outcome variable and the causal variables can be found (Ragin, 1987). The reasons for using QCA in this paper are as follows: firstly, this paper investigates a causal complexity research question. Factors for operating PDPs are diversified and interdependent relationships among these factors may exist, resulting in the difficulty in using quantitative methods to conduct correlation analysis (Skarmeas et.al, 2014). Secondly, this paper collects a medium size of samples (34) where QCA is applicable (Fiss, 2011).

According to different types of variables, QCA includes two analytical techniques, namely csQCA and fsQCA (Ragin,2008). csQCA converts the value of variables into 0 or 1, but this process will lead to a loss of information, while fsQCA can avoid it by converting the value of variables into fuzzy membership between 0 to 1 through calibration. Hence, this paper uses fsQCA to explore the configurational paths that will ensure the PDPs success.

3.2. Sample

The sample selection of the Chinese PDPs is based mainly upon the following standards; the selected PDPs should have theoretical functions, like promoting patent transactions or providing feasible innovation solutions for innovators, and they should belong to one type of digital platform, transaction platform or innovation platform (Wang, 2010). A transaction platform can promote the exchange of services and information between different parties in the multilateral market without any consideration of time or space, as seen in Airbnb and Facebook (Bonina et.al.,2021). Innovation platforms can provide various interfaces that will facilitate different types of innovation, which then attracts more participants to further develop its ecosystem, such as Microsoft Windows, Google Android or Apple iOS (Nambisan et al.,2019). Furthermore, due to the lack of panel data regarding PDPs, the availability of data needs to be considered (Gredel et al.,2012). 34 Chinese PDPs have been selected as the sample in this paper, as shown in **Table 1** below.

TABLE 1 Selected Samples

Case ID	PDP Name	Location	Case ID	PDP Name	Location
1	Baiten	Jiangsu	18	Jshzip	Jiangsu
2	Sixlens	Zhejiang	19	Zbjipr	Chongqing
3	Cnuip	Jiangsu	20	Vipzhuanli	Tianjin
4	Qxtip	Beijing	21	Iluhao	Beijing
5	Shengzhihua	Shanghai	22	Biaotianxia	Guangdong
6	Zhiguagua	Beijing	23	Cnipr	Beijing
7	GaoHangip	Guangdong	24	Maizhi	Zhejiang
8	Ciprun	Beijing	25	Lotut	Anhui

9	7ipr	Guangdong	26	Gowell	Hebei
10	IPOnline	Beijing	27	Zxipz	Jiangxi
11	SSIPEX	Shanghai	28	Huahuize	Shandong
12	SIPOP	Beijing	29	Yitongip	Henan
13	SINOIP	Shanghai	30	Xinyangrui	Inner Mongolia
14	UIPPLUS	Wuhan	31	Sinofaith	Shanghai
15	Qihaoip	Guangdong	32	Paitn	Guizhou
16	CHOFN	Sichuan	33	Dfmark	Liaoning
17	Sipc26	Guangdong	34	Zscqtg	Yunnan

Sources: The official website of PDPs.

3.3. Variables and Data Sources

The DEA value of a PDP's operating efficiency is selected as the outcome variable in this paper. Since DEA requires DMU to have multiple inputs and output variables, an evaluation system for a PDP's operating efficiency is issued according to the references shown in **Table 2** below. The data for these variables has been obtained from the official websites of China National Intellectual Property Administration (CNPIA) and each PDP.

TABLE 2 Evaluation System for PDP's Operating Efficiency

Index	Variables	Definition/Explanation	References
Inputs	Paid-in Capital	The amount of capital that shareholders invest in a company.	Monk (2009)
	Service Category	Patent services often include patent agency, lawsuit, analysis, transaction, pledge, productization, training, government qualification accreditation and database establishment. Total amount of services provided by a PDP is to be considered.	Feller et al (2012)
	Workforce	Total amount of employees in a PDP.	Chu (2013)
Outputs	Governmental Qualification Accreditation	The governmental qualification provided by CNPIA or WIPO, including: National High-Tech Enterprise[3], National Pilot of Patent Operation[4], National Intellectual Property Service Brand[5], World Intellectual Property Organization-Technology and Innovation Support Center (WIPO-TISC)[6] and National Intellectual Property Analysis and Evaluation Brand[7]. Total amount of accreditations a PDP has is to be considered.	Thumm (2018)
	Intellectual Property Application	The numbers of patent, trademark and software copyright that a PDP has applicated is to be calculated.	Agrawal et.al (2016)

Sources: The authors.

Several factors are identified as causal variables. Technological context includes factors such as the local construction of digital infrastructure and the local size of digital industries. The digital infrastructure index and digital industry size index of a region where a PDP is located are the measure indicators, and their data comes from the 'White Book of China Digital Economy Development Index' in 2020[8]. Organizational context includes factors such as size of the business, knowledge assets and reputation. The number of subsidiaries, granted patents and trademark, and positive internet news are the measure indicators, and their data comes from the official websites of PDPs. Environmental context includes factors such as patent intensity, patent market demands and patent system protection. The patent creation index, patent commercialization index and patent system index of a region where a PDP is located are the measure indicators, and their data comes from the 'Evaluation Report on China's Intellectual Property Development' in 2020[9].

The variables in this paper are annual indicators and the benchmark year is 2020.

3.4. Calibration of Variables

Calibration of variables is an important step in fsQCA and the focus point is to convert raw data into set membership scores that range from 0 to 1. During this process, the setting of an anchor point is critical. According to Ragin (2008), the direct method that uses three qualitative anchors for calibration is common with regards to QCA. It sets the threshold for full membership (fuzzy score=0.95), the threshold for full non-membership (fuzzy score=0.05) and the crossover point (fuzzy score=0.5). The three qualitative anchors are generally set based on the researcher's theoretical and substantive knowledge. This study sets three scale values (25th, 50th and 75th percentiles) as qualitative anchors for each variable. A full non-membership is coded if a variable of a PDP shows values of the 25th percentile or below, a full membership is coded if a variable of a PDP shows values of the 90th percentile or higher and the crossover point is set at the 50th percentile of each variable. The result of calibration is shown in **Table 3** below.

TABLE 3 Result of Calibration

Variables	Full membership	Crossover point	Full non-membership
Outcome Variable			
Operating Efficiency	1.00	0.64	0.46
Causal Variables			

The Local Construction of Digital Infrastructures	51.50	45.25	37.50
The Local Size of Digital Industries	81.80	64.60	23.93
Firm Size	7.50	2.50	1.00
Knowledge Assets	81.75	21.50	4.00
Reputation	132.00	69.50	18.50
Patent Intensity	72.30	55.50	51.00
Patent Market Demands	70.70	59.00	46.90
Patent System Protection	79.40	54.40	44.80

Sources: The authors.

4. Results and Discussion

After calibration, this section will identify the configurational paths to aPDP's successful operation based on the following steps. The first step is to analyze the results of operating efficiency found within Chinese PDPs, and then an analysis of necessary conditions is conducted to determine whether there are necessary factors to ensure PDP success. According to Ragin (2008), when the consistency score exceeds 0.9, the causal variable can be considered as a necessary condition for the outcome variable. The second step is to construct a truth table to identify combinations of conditions that are logically sufficient for the presence of PDP success by setting consistency threshold (>=0.8) and frequency cutoff (=1) (Peng et.al.,2022). A standard analysis is then performed to generate the parsimonious, intermediate and complex solutions. The intermediate and parsimonious solutions can distinguish whether a causal variable is a core or peripheral cause. Finally, there is a robustness check to strengthen the reliability of results.

4.1. The Operating Efficiency of Chinese PDPs

As shown in **Table 4** below, there are 11 PDPs that reach the most optimal operating efficiency, accounting for 32.35% of the total number. More than two-thirds of PDPs' operating efficiency is lower than 1. The result demonstrates that it is not simple to operate PDPs successfully in China. 11 Chinese PDPs are successfully operated and the paths to their success will be identified through necessary conditions, analysis and sufficiency analysis.

TABLE 4 Operating Efficiency of PDPs in China

Case ID	Operating Efficiency	Case ID	Operating Efficiency
1	1.00	18	1.00
2	1.00	19	0.33

3	0.36	20	0.50
4	0.82	21	0.87
5	1.00	22	0.56
6	0.49	23	0.47
7	1.00	24	1.00
8	0.59	25	1.00
9	0.36	26	0.75
10	1.00	27	1.00
11	1.00	28	0.64
12	0.31	29	0.63
13	0.20	30	0.23
14	0.40	31	0.64
15	0.72	32	1.00
16	0.50	33	0.53
17	0.18	34	0.78

Sources: The authors.

4.2. Necessary Conditions Analysis for PDP Success

As shown in **Table 5** below, the consistency scores of eight factors are lower than 0.9, which means there are no necessary conditions to ensure a PDP's success. This shows that the outcome of PDP success relies upon the combination of factors, rather than the impact of any single one. The configurational paths to PDPs' success are identified next.

TABLE 5 Analysis of Necessary Conditions for PDP Success

Context	**Variables**	**High Operating Efficiency**	
		Consistency	**Coverage**
Technology	The Local Construction of Digital Infrastructures	0.515993	0.521226
	~ The Local Construction of Digital Infrastructures	0.538875	0.541784
	The Local Size of Digital Industries	0.515001	0.531090
	~ The Local Size of Digital Industries	0.549790	0.541727
Organization	Firm Size	0.366624	0.397029
	~Firm Size	0.680072	0.640869
	Knowledge Assets	0.485699	0.501567
	~Knowledge Assets	0.569169	0.560080
	Reputation	0.460600	0.474219
	~Reputation	0.590182	0.582431
Environment	Patent Intensity	0.783388	0.517227
	~ Patent Intensity	0.256304	0.545330
	Patent Market Demands	0.782863	0.510914

~ Patent Market Demands	0.277259	0.612982
Patent System Protection	0.790392	0.510038
~ Patent System Protection	0.267978	0.616159

Sources: The authors.

4.3. Sufficiency Analysis for Configurational Paths to PDP Success

All the causal conditions appearing in the parsimonious solutions are defined as core causes, while all the causal conditions appearing in the intermediate solutions, but excluded by the parsimonious solutions, are defined as peripheral causes (Fiss, 2011). Considering the intermediate and parsimonious solutions, the results of fsQCA are shown in **Table 6** below. Two configurational paths to PDPs' success are identified in that the acceptable consistency score is higher than 0.8 and the total solution coverage is 0.29. The configurational path 1 can be called 'firm size driven', and the configurational path 2 can be called 'digital infrastructure and knowledge assets driven'. The two paths will further be explained in this section.

TABLE 6 Configurational Paths to PDP Success

Contexts	Configurations	High Operating Efficiency	
		1	2
Technology	The Local Construction of Digital Infrastructures	⊕ (large)	● (large)
	The Local Size of Digital Industries	⊕ (small)	● (small)
Organization	Firm Size	● (large)	⊕ (large)
	Knowledge Assets	● (small)	● (large)
	Reputation	⊕ (large)	● (small)
Environment	Patent Intensity	● (small)	● (small)
	Patent Market Demands	● (small)	● (small)
	Patent System Protection	● (small)	● (small)
Consistency		0.835616	0.856383
Raw Coverage		0.071212	0.093976
Unique Coverage		0.054284	0.023932
Solution Coverage		0.294245	
Solution Consistency		0.853752	
Case ID		25,27,32	1,2,5,7,10,11,18,24

Note: Large full circles (●) indicate the presence of a core causal condition, large crossed-out circles (⊕) indicate the absence of a core causal condition, small full circles (●) indicate the presence of a peripheral causal condition, small crossed-out circles (⊕) indicate the absence of a peripheral causal condition.

Sources: The authors.

4.3.1. Path 1-Firm Size Driven

The configurational path 1, referred to as 'firm size driven', means that, even located in a region where technological context needs to be improved, and where there is a lack of reputation, a PDP can still achieve success by expanding its size. In regions where the construction of digital infrastructures and the size of digital industries are yet to be developed, demands from the patent markets are relatively simple, such as patent application, selling or licensing. In addition, it is difficult for patent sellers/buyers within these regions to find suitable patent buyers/sellers. PDP within these regions can still achieve success, however, mainly due to their large business size (Lichtenthaler & Ernst, 2008; Hagiu & Yoffie, 2013); for instance, Lotut was established in 2008 by Intelligent Dragon Totem Intelligent Property Co., Ltd., headquartered in Hefei City, Anhui Province. According to the 'White Book of China Digital Economy Development Index' in 2020, the digital infrastructure index of Anhui ranks at only 19th among the 31 provinces in China, which is below the average. Under such circumstances, Lotut has implemented a strategy to expand the size of the business. 9 subsidiaries have been set up throughout major cities in Anhui, covering emerging industrial sectors such as biomedicine, information technology, energy-saving and environmental protection. One of the most significant functions of these subsidiaries is to connect innovators throughout these industrial sectors and discover their demands for patents. Owing to the initiative link to local innovators in different industries, Lotut has developed a variety of patent services, such as patent agency, patent analysis and patent commercialization. The larger business size has accelerated Lotut to construct and develop its value network in Anhui, which supports local government, high-tech enterprises, universities, and individual inventors. To date, more than 20,000 customers have cooperated with Lotut. Taking the cooperation with local government as an example, the construction of patent public service platforms of Xiangshan County, Ninghai County and Hefei City are inseparable from the Application Programming Interface (API) data service provided by Lotut. These platforms have provided supports for local government to master the status of a patent within a specific region more accurately, and then to formulate innovation policies through patent analysis.

Reputation is not the focal factor required for the successful operation of PDPs that are located throughout these regions. This is possibly because innovators in these regions have not yet formed a profound understanding of the value of patents for innovation. Innovators still know little about PDPs, a new business model of patent intermediaries, which requires PDPs to actively attract the attention of innovators and establish collaborative relationships with innovators in different cities.

Firm size driven PDPs have played an important role within the regional patent market where technological context needs to be improved. They can discover basic demands, such as patent application, selling or licensing, from innovators in various industries by establishing subsidiaries throughout different cities (Andries & Faems, 2013). Furthermore, they can help government, universities and high-tech enterprises to capture technological development trends and innovation dynamics through patent analysis, especially in regions where are still lack of awareness among local innovators to realize their patent’s value for innovation (Evangelista et.al.,2020). The conclusion is that patent analysis for different innovators can support their decisions on R&D or innovation policies (Ardito et.al., 2018).

4.3.2. Path 2- ‘Digital Infrastructure and Knowledge Assets Driven’

The configurational path 2, referred to as ‘digital infrastructure and knowledge assets driven’, means that although PDPs are a SME, it can still achieve success due to the support from local digital infrastructures and accumulation of knowledge assets. Due to the agglomeration of high-tech business enterprises and universities throughout regions where digital infrastructures are developed, demands from the patent markest are much more complex, not only including demands such as patent applications and selling or licensing, but also patent pledge, securitization and insurance. To satisfy these demands, it is necessary to provide high value-added patent services. Hence, it is important for PDPs in these regions to make full use of local digital infrastructure in order to process the massive patent data and accumulate knowledge assets during said process (Henfridsson & Bygstad, 2013; Chae, 2019). For instance, Jiangsu Baiten Technology Co., Ltd., with its headquarters in Changzhou City, Jiangsu Province, established Baiten in 2012, and it can be seen as a region with abundant digital innovation resources; its digital infrastructure index ranks 3rd in China. Based on this regional advantage, Baiten is committed to developing more valuable services through utilizing digital infrastructure and accumulating knowledge assets that will satisfy complex demands arising from these regions.

The empowerment from local digital infrastructure. Due to both the complex and personalized demands from Jiangsu's patents' market, Baiten's competitiveness lies in providing customers with high-value added services. Nevertheless, the total amount of data concerning global patents has reached 100 million, with each patent having more than 200 analytical dimensions, which leads to a necessity of having to handle more than 10 billion volumes of data. Furthermore, in order to satisfy differing customer demands, more than 100 analytical models should be used to capture valuable information from big data; this is both time-consuming and inefficient. Therefore, the Shujia platform, a cloud computing platform developed from Alibaba Cloud Computing Co., Ltd., has been selected by Baiten because of its powerful capabilities pertaining to machine learning, data storage and analysis. With the optimization from the Shujia platform, the processing and analysis of raw data can be effectively compressed to 3-6 hours; without the Shujia platform this process takes 7 days. More new service concepts such as 'Collection for Patent Product' and 'Zhuanlibaba' can then be developed with the support from Shujia platform.

The accumulation of knowledge assets. The embedding of digital technologies within patent services comprises the core competence of Baiten. It is important to protect the fruitful results of these innovations and take intellectual property as a defensive weapon, especially with regards to the innovation of databases and the model for patent analysis. Baiten has accumulated 141 patents and 77 trademarks and these knowledge assets are not only the sources of value co-creation, but also the safeguard of Baiten's impacts upon regional development.

Digital infrastructure and knowledge assets driven PDPs have played an important role within the regional patent markets where technological context has developed. Although peer competitors have accumulated throughout these regions, they can rapidly respond to complex and personalized demands, that are related to patents, from local innovators; demands such as patent pledge, securitization and insurance, through patent analysis and patent transactions, along with the empowerment from local digital infrastructure (Ardito et.al., 2020). Furthermore, the accumulation of knowledge assets has ensured that the element of competitiveness has remained within the patent market, and this is the foundation that will enable the creation of future service concepts. (Kramer et al., 2011).

4.3.3. Common Antecedent Conditions

Factors throughout the environmental context are peripheral causal conditions for the two configurational paths to ensuring the success of PDPs. The success of PDPs in China is inseparable from the continuous improvement of its patent system. Since the promulgation of ‘the Outline of the National Intellectual Property Strategy’ in 2008, China has successively issued policies, such as ‘Opinions on Deepening the Implementation of the National Intellectual Property Strategy’, to motivate and support the development of PDPs. The perfection of the Chinese patents’ system has the following roles; firstly, it can encourage innovators to carry out patent commercialization activities, which creates market demands. Secondly, it protects patent rights, which ensures the profit gained from commercializing patents. Thirdly, it promotes the surge in patent applications and allocates resources for operating PDPs. Hence, patent system is not the core factor, yet it can still promote the development of the PDPs by stimulating patent market demands, protecting patent rights, and increasing patent intensity (Reiffenstein, 2009; Caviggioli & Ughetto, 2013).

4.4. Robustness Check

This paper conducts a robustness check that examines the sufficient analysis for configurational paths to the success of PDPs. Specifically, this paper reruns the sufficiency analysis with a higher PRI consistency (PRI⩾0.8, compared with PRI⩾0.7 used in the previous model). The configurations remain the same, as shown below in **Table 7.**

TABLE 7 Results of Robustness Check

Contexts	**Configurations**	**High Operating Efficiency**	
		1	2
Technology	The Local Construction of Digital Infrastructures	⊕	●
	The Local Size of Digital Industries	⊕	●
Organization	Firm Size	●	⊕
	Knowledge Assets	●	●

Environment	Reputation	⊕	●
	Patent Intensity	●	●
	Patent Market Demands	●	●
	Patent System Protection	●	●
Consistency		0.835616	0.840365
Raw Coverage		0.071212	0.129057
Unique Coverage		0.054284	0.056678
Solution Coverage		0.327857	
Solution Consistency		0.853752	

Sources: The authors.

5. Conclusion

This paper answers the research question: *what kind of conditional configurations lead to the PDPs' successful operation in China?* Based on the conceptual model, the key factors associated with PDP success, the configurational paths that are identified and by adopting a mixed method of DEA and QCA, the findings reveal that: 1) In our sample, more than two thirds of PDPs are operated unsuccessfully, which means that there is difficulty to be found when endeavoring to operate PDPs in China. The success of PDPs needs to be triggered by a combination of technological, organizational, and environmental factors, rather than any single one. 2) Firm size, knowledge assets and the local construction of digital infrastructures are core conditions required to ensure the success of PDPs, yet environmental factors are peripheral conditions. 3) Two configurational paths to the successful operation of PDPs are identified according to the technological context where a PDP is located, namely, 'firm size driven' and 'digital infrastructure and knowledge assets driven'. 'Firm size driven' pertains to PDPs that located in regions where technological context needs to be improved can still achieve success through enlarging their size. The term 'Digital infrastructure and knowledge assets driven' denotes the PDPs that located in regions where technological context has developed can achieve success by utilizing local digital infrastructure to provide high value-added patent services, and accumulating knowledge assets during this process. Our findings provide several theoretical and practical implications related to PDP.

5.1. Theoretical Implications

During previous studies, several factors have been highlighted that are pertinent to operating patent intermediaries, such as patent system protection, reputation, firm size, the unique effect of Internet and ICT (Wang, 2010; Gredel, 2012). However, little research has connected these factors together in a holistic perspective. Our study has thereby proposed a conceptual model that categorizes these factors into three contexts - technology, organization and environment - from a configurational perspective. Through applying configuration theory, we recognize that different paths exist for ensuring the success of PDPs and each factor may be useful or useless within each path (Miller, 2017). These findings have made contributions toward gaining a better understanding of the causal complexity of patent intermediaries in the digital age (Caviggioli & Ughetto, 2013).

Our study has also explained the reasons why PDPs can both promote patent transactions and provide feasible solutions to customers throughout the patent markets (Thumm, 2018). Prior literatures have focused upon the unique effect of the internet and ICT upon PDPs, yet they have ignored the heterogeneous technological context in different regions and the impact of other factors (Petrusson, 2010). In this paper, we have proved that technological context is not a necessary condition needed to ensure the success of PDPs in China. As a matter of fact, some literatures investigating SMEs in developing countries have also come to the same conclusion (Bala & Feng, 2019). The result of the research undertaken during the writing of this paper demonstrates that even located in a region where technological context needs to be improved, PDPs can achieve success by expanding their size, which shows that the use of digital technologies is currently not indispensable for operating PDPs in China. Furthermore, even if a PDP located in a region where technological context has developed, except for the empowerment of digital infrastructure, PDPs also need to accumulate knowledge assets, in order to achieve successful operations. Therefore, PDPs in both regions can support local innovators in capturing technological development trends and innovation dynamics through patents analysis, and facilitate patent transactions, yet the use of digital technology alone cannot ensure the successful operation of PDPs (Petruzzelli et.al.,2015).

The third theoretical contribution of this paper is to reveal the successful experiences of PDP operations in China, a country featured with the evolving patent market (Hagiu & Yoffie, 2013; Agrawal et al., 2016). PDPs in developed countries such as the USA and France are mostly market-oriented (Liang et.al., 2022). However, for PDPs in China, because the emergence and development of the patents' market is a top-down process led by the Chinese government, the prominent support of the government is required in order to motivate operations, although it is not the core condition for their success. This finding has enriched our understanding regarding the successful operation of PDPs in countries where the patent markets are evolving, and it has also contributed to the literature that can be found upon patent intermediaries with new empirical evidence from a representative developing country (Villani et al.,2016).

5.2. Practical Implications

From a practice perspective, the findings in our paper have important implications for policy makers. For policy makers in regions where technological context needs to be improved, it is important to construct local digital infrastructures, even though firm size is currently the core factor for PDP success throughout these regions. Owing to economic developments, patent market demands in these regions will be much more complex and personalized. If the construction of local digital infrastructures cannot catch up with satisfying these demands, the current successful PDPs will become unsuccessful in the future, because PDP is essentially driven by digital technologies. Therefore, the 5G network, data center, intelligent computing center and any other digital infrastructures are necessary for these regions in order to make a greater contribution to empower the PDPs operation. Furthermore, PDPs with a positive future can be selected to undertake more significant roles within the patent markets. Due to limited resources, the number of PDPs in these regions are comparatively less than in developed regions. Consequently, the allocation of resources can be centered on key PDPs and local government can develop an evaluation system for selecting these PDPs. If a PDP has been selected, it can receive a variety of support from government in the following 3 years, such as subsidies, tax incentives or public services purchase, therefore enabling the selected PDPs to be the key node of regional innovation network. After 3 years, the support from the government will be terminated and the PDPs will need to apply for recertification by meeting the requirements of the evaluation system.

For policy makers in regions where technological context is developed, a strong protection of the patents' system is important because foreign enterprises entering the Chinese patent markets will trigger increased patenting and new ways of patent commercialization, such as patent insurance, patent investment funds and patent securitization. The patent system can strengthen the protection of patent rights whilst regulating the behavior of participants. Moreover, local government can carry out projects that will integrate local digital infrastructures with patent services, therefore establishing industrial standards. Local digital infrastructures are encouraged to support PDPs through algorithms, data and computing. Finally, local government can organize expert forums that will introduce the importance of knowledge assets accumulation. Knowledge assets accumulation can also be used as an indicator for local government to examine the performance of the PDP operations.

5.3. Limitations and Future Research

There are some study limitations to be found in this paper, which offers opportunities for future research. Firstly, a holistic view on PDP operations has been proposed in this paper, yet the influencing mechanism of some contexts still needs to be further analyzed; for instance, due to the prominence of innovation environments, future researchers should concentrate upon the impact that innovation environments have upon a PDPs performance, extending the findings on indirect factors related to PDP operations. Secondly, this paper focuses on how PDPs are successfully operated in China. Meanwhile, some discussions can also be found in previous research regarding developed countries (Wang, 2010; Alvarado, 2013). In the future, researchers can conduct a comparative case study between PDPs in developed countries and developing countries through undertaking an analysis of their similarities and differences.

Notes

1.Data Source: Global Innovation Index 2021, published by World Intellectual Property Organization (WIPO). https://www.wipo.int/global_innovation_index/en/.

2.Data Source: Review of The Construction of Intellectual Property Operation Service System in 2020, published by CNIPA.
https://www.cnipa.gov.cn/art/2021/12/27/art_53_172460.html.

3.National High-Tech Enterprise: this refers to resident enterprises that have been registered in China for more than one year and continuous R&D and transfer of technological achievements that form the core independent intellectual property rights and carry out business activities positively.

4.National Pilot of Patent Operation: A project released by CNIPA in 2013, which explores the integration of patent information analysis and industrial operation decision-making before connecting patents to industrial innovation ability.

5.National Intellectual Property Service Brand Cultivation Organization: A project released by CNIPA in 2012, which cultivates and supports a batch of IP service organizations with large-scale, professional abilities and international scope.

6.Technology and Innovation Support Center (TISC): A project released by the World Intellectual Property Organization (WIPO), which provides local superior technical information and related services to innovators in developing countries and helps them develop their innovativeness and thus create, protect and manage their IP.

7.National Organization for Intellectual Property Analysis and Evaluation: A project released by CNIPA in 2012, which cultivates a batch of service organizations that have outstanding abilities in IP analysis and evaluation.

8.White Book of China Digital Economy Development Index: An annual report released by CCID Consulting Co., Ltd., this is the first quarterly digital economy monitoring index released online in China.

9.Evaluation Report on China's Intellectual Property Development： An annual report released by Intellectual Property Development & Research Center of CNIPA since 2015. The Report includes the "National and Regional Intellectual Property Development Evaluation Index System". The index system includes 60 indicators such as creation, application, protection and environment.

References

Agrawal, A., Bhattacharya, S., & Hasija, S. (2016). Cost-reducing innovation and the role of patent intermediaries in increasing market efficiency. *Production and Operations Management*, 25(2): 173-191. doi:10.1111/poms.12391.

Alvarado L K. (2010). The patent transactions market-established and emerging business market. Goteborg, Chalmers University of Technology.

Andries, P. & Faems, D. (2013). Patenting Activities and Firm Performance: Does Firm Size Matter? *Journal of Product Innovation Management*, 30(6): 1089-1098. doi:10.1111/jpim.12047.

Antonio, J., Revilla, Zulima, & Fernández. (2012). The relation between firm size and R&D productivity in different technological regime. *Technovation*, 32(11): 609-623. doi: 10.1016/j.technovation.2012.06.004.

Appio, F. P., Frattini, F., Petruzzelli, A. M., & Neirotti, P. (2021). Digital Transformation and Innovation Management: A Synthesis of Existing Research and an Agenda for Future Studies. *Journal of Product Innovation Management*,38: 4-20. doi:10.1111/jpim.12562.

Ardito, L., D’Adda, D., Petruzzelli, A. M. (2018). Mapping innovation dynamics in the Internet of

Things domain: Evidence from patent analysis. *Technological Forecasting and Social Change*, 136(11):317-330. doi:10.1016/j.techfore.2017.04.022.
Ardito, L., Petruzzelli, A. M., Albino, V., & Garavelli, A. C. (2020). Unveiling the technological outcomes of microgravity research through patent analysis: implications for business and policy. *IEEE Transactions on Engineering Management*, 69(6):1-12. doi:10.1109/TEM.2020.3010301.
Ardito, L., Petruzzelli, A. M., Dangelico, R.M., & Albino, V. (2014). Understanding the development trends of low-carbon energy technologies: A patent analysis. *Applied Energy*, 135(12): 836-854. doi:10.1016/j.apenergy.2014.08.012.
Arora, A. & Ceccagnoli, M. (2006). Patent Protection, Complementary Assets, and Firms' Incentives for Technology Licensing. *Management Science*, 52(2): 293-308. doi: 10.1287/mnsc.1050.0437.
Bala, H., & Feng, X. (2019). Success of small and medium enterprises in Myanmar: Role of technological, organizational, and environmental factors. *Journal of Global Information Technology Management*, 22(1):1-20. doi:10.1080/1097198X.2019.1603511.
Baldwin, C. Y. & Henkel, J. (2015). Modularity and intellectual property protection. *Strategic Management Journal*, 36(11): 1637-1655. doi:10.1002/smj.2303.
Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, 17(1), 99–120. doi: 10.1177/014920639101700108.
Beltagui, A., Rosli, A., & Candi, M. (2020). Exaptation in a digital innovation ecosystem: The disruptive impacts of 3D printing. *Research Policy*, 49(1): 103833. doi:10.1016/j.respol.2019.103833.
Benassi, M. & Di Minin, A. (2009). Playing in between: patent brokers in markets for technology. *R&D Management*, 39(1):68-86. doi:10.1111/j.1467-9310.2008.00537. x.
Bonina, C., Koskinen, K., Eaton, B., & Gawer, A. (2021). Digital platforms for development: Foundations and research agenda. *Information Systems Journal*,31(1):869-902. doi:10.1111/isj.12326.
Boudreau, K. J., Jeppesen, L. B., & Miric, M. (2022). Profiting from digital innovation: Patents, copyright and performance. *Research Policy*, 51(5): 104477. doi:10.1016/j.respol.2022.104477.
Calof,J. L. (1994). The Relationship Between Firm Size and Export Behavior Revisited. *Journal of International Business Studies*,25(2):367-387. doi:10.1057/palgrave.jibs.8490205.
Caviggioli, F. & Ughetto, E. (2013). The drivers of patent transactions: corporate views on the market for patents. *R&D Management*, 43(4):318-332. doi:10.1111/radm.12016.
Caviggioli, F. & Ughetto, E. (2016). Buyers in the patent auction market: Opening the black box of patent acquisitions by non-practicing entities. *Technological Forecasting and Social Change*, 104:122-132. doi:10.1016/j.techfore.2015.11.031.
Chae, B. (2019). A General framework for studying the evolution of the digital innovation ecosystem: The case of big data. *International Journal of Information Management,*45(2):83-94. doi:10.1016/j.ijinfomgt.2018.10.023.
Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*,2(6):429-444. doi:10.1016/0377-2217(78)90138-8.
Chu, K.-M. (2013). Motives for participation in Internet innovation intermediary platforms. *Information Processing & Management*, 49(4): 945-953. doi:10.1016/j.ipm.2013.02.006.
Clarke, W. (2016). Sovereign Patent Funds: Sovereign Wealth Funds 2.0? *Global Policy*, 7: 577-583. doi:10.1111/1758-5899.12353.
Dushnitsky G, Klueter T. (2017). Which industries are served by online marketplaces for technology? *Research Policy*, 46(3): 651-666. doi:10.2139/ssrn.2447562.
Evangelista, A., Ardito, L., Boccaccio, A., Fiorentino, M., Petruzzelli, A. M. & Uva, A.E. (2020). Unveiling the technological trends of augmented reality: A patent analysis. *Computers in Industry*, 118: 1-15. doi:10.1016/j.compind.2020.103221.

Feller,J., Finnegan,P., Hayes,J., & et.al. (2012). 'Orchestrating' sustainable crowdsourcing: A characterization of solver brokerages. *The Journal of Strategic Information Systems*, 21(3):216-232. doi:10.1016/j.jsis.2012.03.002.

Fischer, T. & Ringler, P. (2015). The coincidence of patent thickets—A comparative analysis. *Technovation*, 38(4): 42-49. doi:10.1016/j.technovation.2014.11.004.

Fiss, P. C. (2011). Building better causal theories: A fuzzy set approach to typologies in organization research. *Academy of Management Journal*, 54(2):393–420. doi:10.5465/AMJ.2011.60263120.

Gambardella A, Giuri P, Luzzi A. (2007). The market for patents in Europe. *Research Policy*, 36(8): 1163-1183. doi:10.1016/j.respol.2007.07.006.

Gawer, A. (2021). Digital platforms and ecosystems: remarks on the dominant organizational forms of the digital age. *Innovation-Organization & Management*, 40(9):1-15. doi:10.1080/14479338.2021.1965888.

Gredel, D., Kramer, M., & Bend, B. (2012). Patent-based investment funds as innovation intermediaries for SMEs: In-depth analysis of reciprocal interactions, motives and fallacies. *Technovation*,32(9):536-549. doi:10.1016/j.technovation.2011.09.008.

Hagiu, A. & Yoffie, D. B. (2013). The new patent intermediaries: Platforms, Defensive Aggregators, and Super-Aggregators. *Journal of Economic Perspectives*, 27(1):45-66. doi:10.1257/jep.27.1.45.

Han, G., & Zhang, Z. (2022). Regional innovation paths selection in complex environments of China: A configurational perspective. *Managerial and Decision Economics*, 43(6):2598–2606. doi:10.1002/mde.3548.

Henfridsson O, Bygstad B. (2013). The generative mechanisms of digital infrastructure evolution. *Mis Quarterly*, 37(3):907-931. doi:10.25300/MISQ/2013/37.3.11.

Jovanovic M., Sjodin D., & Parida V. (2021). Co-evolution of platform architecture, platform services, and platform governance: Expanding the platform value of industrial digital platforms. *Technovation*,6(1):1-14. doi:10.1016/j.technovation.2020.102218.

Kafouros, M., Aliyev, M., & Krammer, M. (2021). Do firms profit from patent litigation? the contingent roles of diversification and intangible assets. *Research Policy*, 50(6): 104263. doi:10.1093/icc/dty074.

Kramer, J. P., Marinelli, E., Iammarino, S., & Diez, J. R. (2011). Intangible assets as drivers of innovation: empirical evidence on multinational enterprises in German and UK regional systems of innovation. *Technovation*,31(9):447-458. doi:10.1016/j.technovation.2011.06.005.

Kwon, S. (2020). How does patent transfer affect innovation of firms? *Technological Forecasting and Social Change*, 154: 119959. doi:10.1016/j.techfore.2020.119959.

Li, S. T., & Tsai, M. H. (2009). A dynamic taxonomy for managing knowledge assets. *Technovation*, 29(4): 284-298. doi:10.1016/j.technovation.2008.10.002.

Li, Z., Li, Y., & Zhang, W. (2021). Configuration analysis of influencing factors of operating efficiency based on fsQCA: evidence from China's property insurance industry. *Chinese Management Studies*,15(5):1085-1103. doi:10.1108/CMS-04-2020-0151.

Liang, K., Ma, L., Liu, Z., Li, T. (2022). Structuring and Operating Patent Intermediary as Platform Ecosystem: Case Studies of Patent Operation Platforms (POPs) in China. *Science, Technology and Society,* 27(2):191-212. doi:10.1177/09717218221074933.

Lichtenthaler, U. & Ernst, H. (2008). Innovation intermediaries: Why internet marketplaces for technology have not yet met the expectations. *Creativity and Innovation Management*,17(1): 14-25. doi:10.1111/j.1467-8691.2007.00461.x.

Lichtenthaler, U., & Ernst, H. (2007). Developing reputation to overcome the imperfections in the markets for knowledge. *Research Policy*, 36(1):37-55. doi:10.1111/j.1467-9310.2007.00487.x.

Lin, H., Zeng, S., Liu, H., & Li, C. (2020). Bridging the gaps or fecklessness? A moderated mediating examination of intermediaries' effects on corporate innovation. *Technovation*, 94-95(6): 102018.

doi:10.1016/j.technovation.2018.02.006.
Ma, L., Liang, K., & Wang, Y. (2021). The development and evolutional trend of Chinese intellectual property operation platform driven by digital technology. *Forum on Science and Technology in China,* 36(9):76–88. doi:10.13580/j.cnki.fstc.2021.10.017.
Meyer,A.D., Tsui,A.S. & Hinings,C.R. (1993). Configurational Approaches to Organizational Analysis. *Academy of Management Journal*, 36: 1175-1195.doi: 10.2307/256809.
Miller, D. 2017. Challenging trends in configuration research: Where are the configurations? *Strategic Organization*, 16(4): 453-469. doi:10.1177/1476127017729315.
Miric, M., Boudreau, K. J., & Jeppesen, L. B. (2019). Protecting their digital assets: The use of formal & informal appropriability strategies by App developers. *Research Policy*, 48(8):1-13. doi:10.1016/j.respol.2019.01.012.
Misangyi,V. F. & A. G. Acharya. (2014). Substitutes or Complements? A Configurational Examination of Corporate Governance Mechanisms. *Academy of Management Journal*,57(6):1681-1705. doi:10.5465/amj.2012.0728.
Monk, A.H.B. (2009). The emerging market for intellectual property: drivers, restrainers, and implications. *Journal of Economic Geography*, 9(4):469-491. doi:10.1093/jeg/lbp003.
Nambisan, S., Zahra, S. A., & Luo, Y. (2019). Global platforms and ecosystems: Implications for international business theories. *Journal of International Business Studies,* 50(9):1464-1486. doi:10.1057/s41267-019-00262-4.
Oliveira, T., Martins, R., Sarker, S., Thomas, M., & Popovič, A. (2019). Understanding SaaS adoption: The moderating impact of the environment context. *International Journal of Information Management,* 49:1-12. doi:10.1016/j.ijinfomgt.2019.02.009.
Park, Y., & Mithas, S. (2020). Organized complexity of digital business strategy: A configurational perspective. *MIS Quarterly,* 44(1): 85–127. doi:10.25300/MISQ/2020/14477.
Peng, C., Jiang, H., Song, H., & Zhang, T. (2022). Does institutional distance affect the risk preference of enterprises' OFDI: Evidence from China. *Managerial and Decision Economics*, 43(5):1209–1223. doi:10. 1002/mde.3448.
Petrusson U., Ros N H., & Thornblad T. (2010). Global technology markets-The role of Open Intellectual Property Platforms. *Review of Market Integration*,23(2):333-392. doi:10.1177/097492921000200307.
Petruzzelli, A. M., Rotolo, D. & Albino, V. (2015). Determinants of patent citations in biotechnology: An analysis of patent influence across the industrial and organizational boundaries. *Technological Forecasting and Social Change*, 91:208-221. doi:10.1016/j.techfore.2014.02.018.
Qiang L., Yang D. & Miao Y. (2021). Supply chain network and financing performance of small and medium enterprises in China: a survey and quasi-replication using fuzzy-set qualitative comparative analysis. *Baltic Journal of Management*, 16(5): 785-803. doi:10.1108/BJM-09-2020-0331.
Ragin,C.C. (1987). The comparative method: moving beyond qualitative and quantitative strategies. Berkeley: University of California Press.
Ragin,C.C. (2008). Redesigning social inquiry: Fuzzy sets and beyond. Chicago: University of Chicago Press.
Reiffenstein T. (2009). Specialization, centralization, and the distribution of patent intermediaries in the USA and Japan. *Regional Studies*, 43(4):571-588. doi:10.1080/00343400701874255.
Skarmeas, D., Leonidou, C. N., & Saridakis, C. (2014). Examining the role of CSR skepticism using fuzzy-set qualitative comparative analysis. *Journal of Business Research*,67(9):1796–1805. doi:10.1016/j.jbusres.2013.12.010.
Sun W., Chen Y., & Sun Q. (2015). Distribution characteristics of patent intensity in Chinese manufacturing industrial and influencing factors. *Science of Science and Management of S.& T*,

36(4):95-104.

Teece, D. J. (2018). Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. *Research Policy*,47(8):1367-1387. doi:10.1016/j.respol.2017.01.015.

Thumm N. (2018). The good, the bad and the ugly-the future of patent assertion entities in Europe. *Technology Analysis & Strategic Management*,30(9):1046-1056. doi:10.1080/09537325.2018.1434875.

Tilson, D., Lyytinen, K., & Srensen, C. (2010). Digital infrastructures: the missing is research agenda. Information Systems Research, 21(4):748-759. doi:10.1287/isre.1100.0318.

Villani, E., Rasmussen, E., & Grimaldi, R. (2016). How intermediary organizations facilitate technology transfer: A proximity approach. *Technological Forecasting and Social Change*,114(1):86-102. doi:10.1016/j.techfore.2016.06.004.

Wang A W. (2010). Rise of the patent intermediaries. *Berkeley Technology Law Journal*, 25(1):159-200.

Yusuf,S. (2008). Intermediating knowledge exchange between universities and businesses. *Research Policy*, 37(8):1167-1174. doi:10.1016/j.respol.2008.04.011.

Zaki M. (2019). Digital transformation: Harnessing digital technologies for the next generation of services. *Journal of Services Marketing*,33(4):429-435. doi:10.1108/JSM-01-2019-0034.