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Development and validation of the intellectual property services scale in China

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ABSTRACT

Existing studies have emphasized the crucial role of intellectual property services (IPS) in the advancement of science and technology, but there was still a lack of a valid scale for assessing IPS. Accordingly, this study aimed to develop a reliable instrument to fill this gap. A three-step process of scale development was described: item generation through grounded theory research (n = 14), scale development through exploratory factor analysis (n = 219) and scale assessment through confirmatory factor analysis (n = 191). By analyzing and coding the interview data drawn from IPS agencies in China, the study verified that IPS could be represented as a three-dimensional construct consisting of vocational skills services (VSS), commercial operation services (COS), and value-added business services (VBS). The subsequent exploratory factor analysis and confirmatory factor analysis were conducted to test and modify the IPS scale with 11 items was shown to have acceptable internal consistency reliability, as well as convergent and discriminant validity. The IPS scale could serve as an operational tool for IPS practitioners to measure and identify the problems of service quality and service mode. Additionally, it held significant theoretical value and practical implications for the advancement of intellectual property services industry in China.

1. Introduction

In developed countries, the intellectual property services (IPS) industry has a history of about 200 years. The long historical practice has fostered a mature and stable market mechanism, where various organizations such as technology transfer offices, science parks, incubators and professional services companies are interdependent, interacting and developing together [1]. This well-established market mechanism not only facilitates the production of high-quality intellectual property products, but also enables innovators to leverage the value of intellectual property through strategic means such as patent blockades, patent jungles, and patent barriers [2,3]. While China had made significant improvements in generating intellectual properties in recent years, it had shown insufficient momentum in intellectual property application and technology transfer. Unlike developed countries, strategic utilization of intellectual property remained scarce [4]. One of the primary reasons for this situation is the lack of comprehensive intellectual property services throughout the various stages of intellectual property creation, application, protection, and management [5,6].

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Especially in the current context of open innovation, with an increasing number of organizations and elements participating in innovation activities, the importance of IPS have grown significantly [7].

Previous studies had typically classified the concept of IPS into two levels, a broad definition and a narrow definition [8,9]. The broad definition of IPS encompasses three main components: the first is intellectual property management services, led by government agencies and industry associations. This component involves creating a policy environment related to intellectual property and providing the public with basic IPS and other public welfare services. The second is intellectual property intermediary services, with commercial IPS agencies as the backbone, and which mainly includes provision to inventors of agency services, legal services, information services, commercialized services, consulting services, training services, and other personalized and professional services. The third is internal IPS, established by the enterprise organization itself, including application, analysis, strategic planning, and other services for the organization's own intellectual property [9,10]. On the other hand, the narrow definition of IPS refers specifically to the service behaviors and activities in the technology, law, economic and other relevant fields involving agency services, information services, legal services, commercialized services, consulting services and training services provided by market-oriented IPS agencies throughout the entire process of intellectual property creation, utilization, protection, and management for their client's innovative achievements [11–13].

As the strategic importance of intellectual property has grown, IPS has been extensively discussed in various studies based on the aforementioned concept [14–16]. These studies have mainly focused on four key aspects: First, most studies have provided descriptions of the current situation, problems and development directions of the IPS in specific areas [15,17]. Second, research on the IPS system have become increasingly rich. Some scholars have examined foreign experiences, constructional strategies and operational mechanisms of IPS system [18,19]. Third, recent topics have centered on discussing how university libraries effectively integrated and leveraged their resources and advantages [20], so as to promote the optimization and development of IPS [21–23], and thus provided innovators or inventors (teachers and students) with consultation and support related to intellectual property [24]. Finally, another prominent topic is the correlation between IPS and technological achievements. Relevant studies have indicated that by improving the quality of application documents writing, communicating with inventors, interacting with examiners, and designing rights protection [10,25,26], IPS could play an essential role in enhancing intellectual property quality and act as a driving force for technology transfer [27,28].

Despite the increasing attention on the importance of IPS, its constitutional dimensions remained unclear, a lack of a valid and reliable scale for measuring multidimensional IPS was observed. In developed countries, due to the existence of a comprehensive intellectual property services system, their IPS industry have been continuously refined and detailed. As a result, most western scholars have not directly referred to the term "intellectual property services" in their research on intellectual property services measurement [29,30]. Instead, they have used terms such as "innovation intermediary" [31], "information intermediary" [32] and "patent broker" [33]. In the Chinese context, only a few of studies have measured the IPS from a specific services business perspective. For instance, Zhang [34] designed a technology transfer services measurement scale based on four dimensions: technical services, information services, relational services, and security services. Yan [35] developed a relevant scale for patent agent competence from the perspective of agency services. However, there still lacks a clear explanation of the dimensions and measurement of IPS, leaving a gap

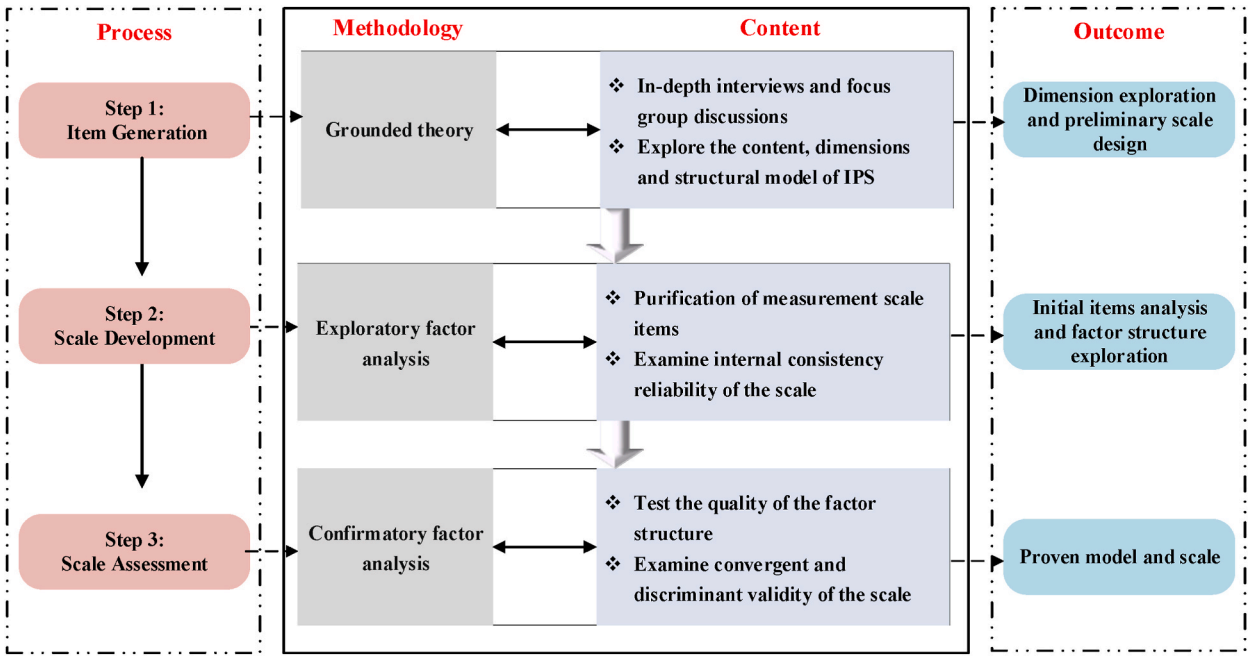

Fig. 1. Development process of intellectual property services (IPS) scale.

in the measurement scale. Furthermore, the limited studies focusing on measuring IPS have employed the method of the simple rational and logic analysis, rather than combining the qualitative study and quantitative study [36]. This hindered the provision of theoretical support for research into IPS. Quantitative measurement is an essential step in transforming management experience into management science to further guide practice. Being one of the exploratory studies on the above issue, this paper aims to give a particular focus on identifying specific dimensions of IPS and construct and validate an effective measurement to assess it.

2. Research methodology and procedure

The goal of this study is to develop and validate a reliable measuring tool for IPS. According to McKim [37], both quantitative and qualitative research have advantages and disadvantages. However, a mixed methods approach, combing quantitative and qualitative research, can lead to the development of a more effective and context-specific instrument by balancing their respective drawbacks. Meanwhile, scholars have generally reached a consensus on employing mixed methods to develop scales. Therefore, this study adopted a combination of deductive and inductive methodologies with mixed methods, allowing both summative derived categories and those correlations randomly arising from data to be considered [38]. This methodology is appropriate as there is currently limited theory to guide the notion about the dimensions and measurement of IPS [39].

To accurately and effectively evaluate a theoretical construct, it is essential to follow a rigorous and systematic procedure of development and validation [40,41]. In this study, a three-step process was adopted to develop the scale of IPS, following Hinkin's [42] widely used guidelines for scale development. Firstly, in-depth interviews were conducted with managers and experts in IPS industry. Grounded theory was then used to analyze the interview data, aiming to explore the dimensions and structural model of IPS. Based on a review of related scales and analysis and discussions of the interview data, the questionnaire draft and initial items were generated. Secondly, exploratory factor analysis (EFA) was performed to explore the factor structure and purify the measurement items. This involved a questionnaire survey with 240 samples, leading to a revised scale comprising 11 items. Finally, confirmatory factor analysis (CFA) was employed to confirm the structure of the IPS scale and examine its reliability and validity in a new sample of 191 respondents, thus the proven model and final scale were then developed. The overall flow with research methodology and procedure was illustrated in Fig. 1, demonstrating the systematic approach and process adopted to develop and validate the IPS scale.

3. Step 1: Item generation

This step aim to explore the structure and dimensions of IPS using grounded theory, create the initial items, and evaluate and improve these initial items through the focus group discussions.

3.1. Methods

3.1.1. Participants

Due to the limited existing research on the dimensions and scale development of IPS, this study adopted the grounded theory method, analyzing data from in-depth interviews to explore the structure and dimensions of IPS and address the gap in the literature left by existing theory and research [43]. We chose IPS agencies in Beijing as the main research sample. The reason for this was that they held a leading position in the Chinese IPS industry in terms of scale, popularity and service quality [8], thus promoting the rapid development of IPS. Additionally, IPS agencies in Dalian were selected for investigation, as the development of the IPS industry in this region was still in its early stage. Many IPS agencies were unable to provide diversified and high-end intellectual property services modes, resulting in relatively low service quality and weak service capability. Therefore, it was of high representativeness to conduct qualitative research on IPS agencies in Beijing and Dalian. Furthermore, for the convenience of data acquisition, IPS agencies in Zhengzhou and Changzhou were also included, as they were either close to the geographical location of the research group members or rich in accessible resources. To complement the qualitative data obtained from interviews, website information, news, and other

Table 1
Details of the selected organizations.

No	Organization	Interviewee	Duration
1	Unitalen Attorneys at Law	Intellectual property consultant	93 mins
2	Sunshine Intellectual Property Group	Vice general manager	106 min
3	Chofn IP	Dean of the Institute of Technology Transfer	205 min
4	Sanyou Intellectual Property Agency	Vice general manager	56 min
5	KingSound & Partners Intellectual Property Law	Patent agent	23 min
6	Dragon Intellectual Property Law Firm	Head of Personnel	30 min
7	Dalian Chicco Patent Agency	General manager	108 min
8	Dalian East Patent Agent LTD	President	46 min
9	Dalian Gezhi Intellectual Property Agency	General manager	68 min
10	Dalian Technology Intellectual Property Agency	General manager	62 min
11	Patent Center of Dalian University of Technology	Patent agent	40 min
12	Dalian Hongmeng Data Technology Co., LTD	General manager	132 min
13	Jiangsu Hengweizhi Information Technology Co., LTD	General manager	60 min
14	HenanYulong Law Firm	Manager of IP Department	115 min

related materials for the surveyed organizations were crawled using Python and combined with literature related to IPS for verification through triangulation. Details of the research objects were presented in Table 1.

3.1.2. Procedure

Research data was collected through various channels: (1) A semi-structured interview outline we designed based on focus group discussions with one professor, one associate professor, and three academics holding PhDs. Subsequently, in-depth interviews were conducted with fourteen Chinese IPS agencies. Respondents described their actual working practices and environment, providing more than 100,000 words of first-hand interview data, which was transcribed from recorded materials. (2) We employed a Python crawler program utilizing the "Requests" and "BeautifulSoup" libraries to automatically gather and process the firm profiles, business content, news reports, and other relevant information from the official websites of the surveyed organizations, and finally acquired an additional set of secondary data, encompassing over 70,000 words of textual information. These secondary data originated from publicly available sources on the official websites of each surveyed company, ensuring compliance with internet regulations. By analyzing the collected data and combining it with the literature related to IPS, a research sample database was constructed. For data analysis, ten IPS agencies were randomly selected, while the remaining four organizations were reserved for the subsequent theoretical saturation test.

Throughout the research process, ethical considerations were paramount. Biomedical and Animal Ethics Committee of Dalian University of Technology issued an approval letter (DUT-2021–0.097). Before participating in the in-depth interviews, all participants were presented with a consent letter detailing the research objectives, non-disclosure of commercial secrets and sensitive topics, confidentiality of participant information, and their right to withdraw from the study at any time.

3.2. Data analysis

Following the programmed grounded theory established by Strauss & Corbin [44], we utilized NVivo11 software to systematically comb and analyze the collected data using a standardized three-level coding program. During the coding process, two specialists with doctorates in the field of intellectual property research independently classified, coded, and logged the interview data. They labeled the interviewees' original words extensively to minimize subjectivity bias. To ensure consistency and accuracy, the coding results were then compared and discussed with two professors and one associate professor. In cases where differing coding results emerged, collaborative discussions were held, leading to re-coding and modification of the coding results as necessary. Finally, two professionals with 10 years of working experience in the IPS industry were invited to review and verify the coding results based on practical expertise.

3.2.1. Open coding analysis

In grounded theory, open coding analysis is the starting point of data analysis. It is the process of summarizing phenomena into concepts and then exploring and refining the categories identified. In this study, more than 600 original sentences and corresponding initial concepts were refined and sorted through summarizing the in-depth interview data from fourteen IPS agencies. Due to the complexity of the initial concepts, some of which had similar or contradictory meanings, we eliminated initial concepts that recurred less than three times or were inconsistent with each other to categorize the initial concepts, and finally obtained 37 initial concepts and 17 initial categories. The open coding results were shown in Appendix.

3.2.2. Axial coding analysis

The main task of axial coding analysis is to explore and establish the internal relations between categories. Based on the results of open coding, we further summarized the initial categories. Then, according to the logical relations between the categories, initial categories were grouped into sub-categories, and then main categories were developed. Finally, nine sub-categories and three main

Table 2
Results of axial coding.

Main categories	Sub-categories	Initial categories extracted from open coding
Vocational skills services	Agency services	Intellectual property application, Contact and communication
	Legal services	Legal lawsuits, Drafting of contracts
	Information services	Intellectual property information retrieval, Legal information retrieval
Commercial operation services	Relationship matching services	Network of relationships, Ability to match supply and demand
	Business communication services	Negotiation ability, Coordinate ability
	Transaction process services	Transaction materials processing, Supervision of transactions process
Value-added business services	Consultation services	Professional consulting business, Managerial consulting business
	Training services	Intellectual property business training, Intellectual property knowledge training
	Assessment services	Comprehensive assessment

categories were formed, as shown in Table 2.

3.2.3. Selective coding analysis

The core work of selective coding analysis is to dig out core categories from the main categories and describe the typical relationship structure in the way of a "story line," based on which a new theoretical framework will be developed [45]. Through in-depth exploration and analysis of the original interview materials and the relationships between main categories and sub-categories, the core category of this study was determined as "intellectual property services", which consisted of three main categories, such as vocational skills services, commercial operation services and value-added business services.

3.3. Results

3.3.1. Dimensions of IPS

We integrated the holographic theory of the knowledge activity system with the technology intermediary system proposed by Xu et al. [46], which was composed of knowledge production services intermediaries, knowledge transfer services intermediaries and knowledge application services intermediaries. Based on these systems and the actual business fields of Chinese IPS agencies, this paper divided the dimensions of IPS into three types: intellectual property production services, intellectual property transfer services and intellectual property application services.

According to the above qualitative research using grounded theory, we identified three main dimensions of IPS: vocational skills services, commercial operation services and value-added business services. On this basis, each dimension was analyzed and explained in detail. Vocational skills services (VSS) primarily supported intellectual property application and acquisition, focusing on the production of intellectual property, that was, corresponding to intellectual property production services. The main function of commercial operation services (COS) was to provide services and support for the intellectual property transfer and licensing process, that was, corresponding to intellectual property transfer services. Value-added business services (VBS) played a role in enhancing the client's technical ability and related willingness, which contributed to improving the quality and commercial value of intellectual property so as to realize the commercial application of intellectual property, that was, corresponding to intellectual property application services. To sum up, the structural model of IPS was constructed, as shown in Fig. 2. Furthermore, we performed coding analysis of the sample data from the four reserved agencies. no new categories, relational structure, or component factors were generated within the main categories. As a result, the structural model was considered to have reached theoretical saturation.

3.3.2. Initial items generation

Currently, research on the development of measurement scale for IPS is very limited. This study aims to fill this gap by conducting exploratory research to analyze the dimensions of IPS and construct the measurement items of IPS. Drawing on the results of grounded theory research and referring to mature scales in existing studies, a preliminary scale of IPS were designed. Further, in-depth interviews and discussions were conducted with six general managers who had over five years of experience working in IPS agencies. Their valuable insights led to the addition of important items to the scale. Finally, focus group discussions were organized with three professors and five academics holding PhDs in the field of intellectual property research, in which each measurement item was carefully reviewed, and necessary corrections were made item by item. Ambiguous or repetitive items were merged or deleted to enhance the legibility and comprehensibility of each item. This rigorous process resulted in the generation of the initial items of IPS, which were detailed in Table 3.

4. Step 2: Scale development

Through grounded theory research, a preliminary scale of IPS was constructed. This study aims to further explore which items should be retained through factor extraction and examine its internal consistency reliability via exploratory factor analysis (EFA).

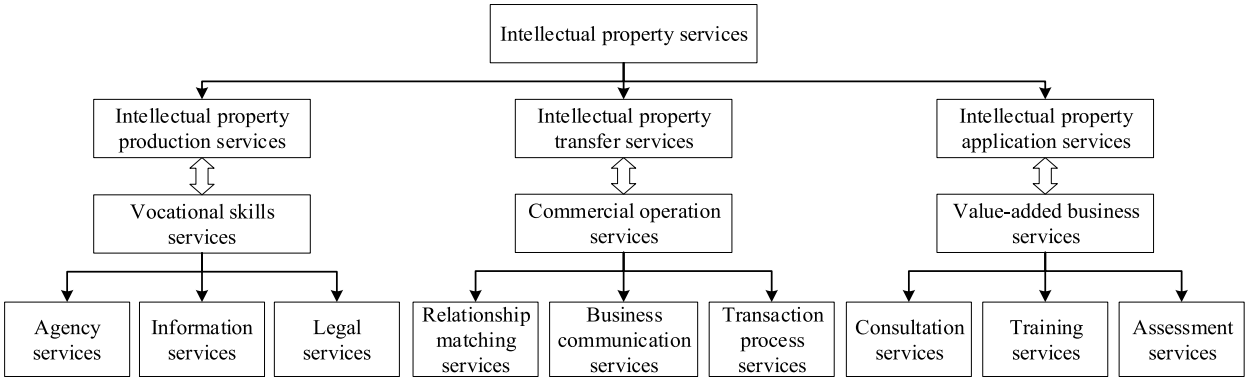

Fig. 2. The dimensions and structural model of IPS.

Table 3
Details of 16 initial items of IPS.

Construct	Item	Statement	Source of items
VSS	VSS1	Through repeated communication with clients, write the most appropriate and well-constructed claims of right, protection scope, and technical solutions.	Yan [35], From in-depth interview
	VSS2	Reply to examination comments as required and on time.	
	VSS3	Provide support and help for clients' infringement lawsuits, invalid lawsuits, and other lawsuits.	
	VSS4	Conduct a comprehensive and systematic search of existing technology.	
	VSS5	Search the peripheral patents around the client's patents.	
COS	COS1	According to information about the intellectual property and market demand, guide both parties in the technology transaction to achieve commercial cooperation.	Gomez [25], From focus group discussions, From in-depth interview,
	COS2	Provide financing services or resources for both parties in the technology transaction according to their requirements.	
	COS3	Have strong negotiation ability to provide support and help to clients with contracts and price details for technology transactions.	
	COS4	Have strong coordination ability to properly resolve conflicts and contradictions between the parties in technology transactions.	
	COS5	Use its own reputation and social relations to provide reputational guarantees for both parties in technology transactions and ensure close cooperation between the parties.	
VBS	VBS1	Analyze related industries for clients through intellectual property navigation services.	Zhang [34], From in-depth interview, From focus group discussions
	VBS2	Provide intellectual property early warning services for clients to avoid potential technology disputes.	
	VBS3	Provide clients with project initiation consultation, intellectual property strategic planning consultation, and other consultation services.	
	VBS4	Train clients on basic knowledge and management processes related to intellectual property.	
	VBS5	Train technicians on intellectual property agency practice and ideology related to technology transactions.	
	VBS6	Assess the value of intellectual property based on analysis of the technology market.	

4.1. Methods

4.1.1. Participants

The data used in EFA were collected from questionnaire surveys. Questionnaires were randomly dispensed to a total of 350 participants and 301 were completed and returned. After excluding 82 invalid questionnaires, 219 valid questionnaires were collected, with an effective rate of 72.76%. Response data are used in this study to show the distribution characteristics of the sample, as shown in Table 4.

4.1.2. Procedure

First, questionnaires including pilot scale and demographic questions were set up on a professional online survey platform and distributed to multiple types of subjects and in multiple regions. Participants accessed the survey through a unique link. Second, leveraging the social connections and resources established by the research team members, invitations were extended to general managers and agents working in IPS agencies to participate in the survey. Finally, some respondents were invited to refer other potential participants who met the research criteria, ensuring a high-quality and diverse pool of participants. This iterative process continued until the desired number of participants was achieved. For the 16 measurement items listed in Table 3, respondents were asked to rate their opinions and actual working practices on a five-level Likert scale, ranging from 1 ('extremely mismatch') to 5

Table 4
Distribution characteristics of the sample: Exploratory factor analysis stage (n = 219).

Attribute	Classification	Quantity	Proportion	Attribute	Classification	Quantity	Proportion
Gender	Male	123	56.2%	Education	Associate degree	45	20.5%
	Female	96	43.8%		Bachelor's degree	81	37.0%
Age	Under 27 years old	40	18.3%		Master's degree	57	26.0%
	28–31 years old	71	32.4%		Doctorate	28	12.8%
	32–35 years old	56	25.6%		Other degree	8	3.7%
	36–39 years old	32	14.6%	Professional title	Primary	43	19.6%
	40–50 years old	13	5.9%		Middle	79	36.1%
	More than 50 years old	7	3.2%		Vice-senior	44	20.1%
Occupation	Employees in IPS agencies/Staff in intellectual property management department/Staff in technology transfer organization/Patent examiners	108	49.3%		Senior	18	8.2%
					Other	35	16.0%
				Years of working	Under 1 year	25	11.4%
					1–3 years	60	27.4%
	Inventors/Technicians	48	21.9%		4–6 years	68	31.0%
	Researchers in intellectual property	32	14.6%		7–9 years	40	18.3%
	Other staff related to intellectual property	31	14.2%		More than 10 years	26	11.9%

('completely match'). Similar to Step 1, this step conformed to all research ethics and privacy rights, and all participants read and signed the consent letter prior to participating in the survey.

4.1.3. Data analysis

Exploratory factor analysis (EFA) is a statistical technique extensively applied in scale development to explore the underlying dimensions and optimal structure of measurement items. When conducting exploratory factor analysis, it is necessary to test whether there is correlation or partial correlation among variables in order to judge the feasibility of exploratory factor analysis [47]. SPSS 20 was used to conduct a Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity to consider the appropriateness of factor analysis, with the criteria to be > 0.50 and < 0.01, respectively [48]. Furthermore, Principal component analysis (PCA) is an adaptive exploratory approach for data processing, compression, and extraction [49]. PCA method with the varimax rotation can find multiple factors to clarify the content of the variable, which was most commonly used and suitable for this study context [50]. Accordingly, the criteria for determining the number of factors to retain were eigenvalues greater than 1, accumulated variance explanation by extracted factors more than 50% and factors containing three or more items [51]. Oppositely, items with factor loading <0.4 and loaded on the factors other than its design will be dropped out of scale.

4.2. Results

4.2.1. Factor analysis

The results showed that the KMO value was 0.824 and the significant level of the Bartlett's test was 0.000 ($\chi^2 = 573.13$), which met the criteria and was suitable for factor analysis.

An eigenvalue greater than 1 was used to decide the number of factors to be extracted [52]. Combining with the principal component analysis method and varimax-rotation method, three factors with initial eigenvalues greater than 1 and the cumulative variance contribution rate of 56.597% were identified, the results was consistent with the structural model of IPS formed from stage 1. Accordingly, a total of 11 items of IPS with the factor loading greater than 0.5 were extracted, and each factor contained more than three items, which also met the acceptable standards [53]. The results of exploratory factor analysis for factor loadings were shown in Table 5. According to the criteria for factor reduction, five items with factor loadings less than 0.4 or loading on multiple factors were deleted, including "VSS2: Reply to the examination comments as required and on time".

4.2.2. Internal consistency reliability

The reliability and validity of the scale were examined to prove their effectiveness. Cronbach coefficient was used to measure the reliability of the questionnaire. In this study, the overall Cronbach's α of the scale with 11 items was 0.810. Meanwhile, Cronbach's α of VSS, COS and VBS reached 0.704, 0.749 and 0.716, which indicated total scale and subscales all obtained excellent internal consistency following that a Cronbach's alpha value above 0.70 was recommended to ensure data reliability [40]. As consequence, all 11 items derived from IPS were worth retaining to the next stage of scale validation.

5. Step 3: Scale assessment

The aim of Step 3 is to test the effect and quality of 3-dimensions and 11-item IPS factor structure obtained from exploratory factor analysis, and further verify the reliability and validity of the IPS scale in a new sample via confirmatory factor analysis (CFA).

5.1. Methods

5.1.1. Participants and procedure

To avoid issues related to common method variance, a new sample was recruited for this step by redistributing the revised questionnaires from Step 2 to a different group of respondents [54]. The distribution methods and scoring criteria of the questionnaire in this step were kept consistent with those in Step 2. Therefore, relevant senior managers and agents in IPS companies were recruited

Table 5
Exploratory factor analysis for factor loadings of IPS.

Factor	Item	Factor loading		
		1	2	3
VSS	VSS1	0.735		
	VSS3	0.708		
	VSS4	0.724		
	VSS5	0.626		
COS	COS2			0.529
	COS4			0.825
	COS5			0.730
VBS	VBS1		0.758	
	VBS2		0.663	
	VBS4		0.766	
	VBS5		0.500	

on a voluntary basis to participant, as well as encouraged to invite colleagues with whom they were familiar to take part in the survey. Meanwhile, to ensure the quality of reply, respondents who faced difficulties in understanding the statements were provided support by researchers during the questionnaire completion process. In total, 280 questionnaires were randomly distributed and 242 were completed and returned. After removing 51 invalid questionnaires, 191 valid questionnaires were finally collected, resulting in an effective rate of 78.93%. The distribution characteristics of the sample in the confirmatory factor analysis stage were presented in Table 6. As in Step 1 and Step 2, this step strictly adhered to research ethics, and all participants read and signed the consent letter before engaging in any survey activities.

5.1.2. Data analysis

For the verification of item-factor relationships and the examination of reliability and validity of the IPS scale, CFA was conducted with a maximum likelihood method on the 11-item IPS. First, the factor model was inspected using AMOS 24. The indices used to assess the fit of the factor model were as follow: the Chi-square divided by degrees of freedom (χ^2/df), Root Mean Square Error of Approximation (RMSEA), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Comparative Fit Index (CFI) and Normed Fit Index (NFI) [55,56]. Second, the value of average variance extracted (AVE) and composite reliability (CR) were also calculated by using AMOS 24 to evaluate the convergent validity of the IPS scale [53]. Finally, correlational analyses and Cronbach's alpha coefficient were conducted using SPSS 20 to respectively assess the discriminant validity and the reliability of the IPS scale.

5.2. Results

5.2.1. Comparison of factor models

Based on the results of the Step 1 and Step 2, we preliminarily proposed that IPS was a concept containing three dimensions and the corresponding scale was composed of 11 items. To further validate the three-factor model proposed in the exploratory factor analysis stage, confirmatory factor analysis was conducted using AMOS 24 [57]. The optimal matching model was determined by calculating and comparing the fit indices of the single-factor model (M1), two-factor model (M2), and three-factor model (M3). The results of the comparative analysis were presented in Table 7. According to the evaluation standard of model fit [58,59]: a value of χ^2/df less than 3 indicated a high degree of model fitting. RMSEA less than 0.08 indicated a reasonable model fit. GFI, AGFI, CFI and NFI greater than 0.9 indicated a good model fit. From Tables 7 and it could be observed that all fit indices for model M3, except for one (AGFI), met the corresponding standards. However, the AGFI value was very close to the standard value. Moreover, M3 demonstrated a better fit compared to the other models, confirming the three-factor structure of IPS.

5.2.2. Reliability assessment

Similar to exploratory factor analysis, KMO test and Bartlett's test of sphericity were used to test the reliability of the scale. The results showed that the KMO test value was 0.916, the Bartlett's test value was 1093.607 ($p < 0.001$). The standardized factor loading of each factor was greater than 0.6, which all met the relevant standards and proved the scale had high reliability. Moreover, we conducted internal consistency reliability test with Cronbach's alpha to describe the extent to which all items in the scale measured the same concept or construct [60]. The overall internal consistency reliability of the IPS scale was 0.915. Accordingly, Cronbach's α of subscales (VSS, COS and VBS) showed a range from 0.751 to 0.853, which all were greater than the criterion level of 0.7, and indicated an acceptable consistency reliability.

Table 6
Distribution characteristics of the sample: Confirmatory factor analysis stage (n = 191).

Attribute	Classification	Quantity	Proportion	Attribute	Classification	Quantity	Proportion
Gender	Male	120	62.8%	Education	Associate degree	30	15.7%
	Female	71	37.2%		Bachelor's degree	70	36.6%
Age	Under 27 years old	35	18.3%		Master's degree	63	33.0%
	28–31 years old	51	26.7%		Doctorate	20	10.5%
	32–35 years old	54	28.3%		Other degree	8	4.2%
	36–39 years old	29	15.2%	Professional title	Primary	30	15.7%
	40–50 years old	13	6.8%		Middle	68	35.6%
	More than 50 years old	9	4.7%		Vice-senior	38	19.9%
Occupation	Employees in IPS agencies/Staff in intellectual property management department/Staff in technology transfer organization/Patent examiners	107	56.0%		Senior	16	8.4%
					Other	39	20.4%
				Years of working	Under 1 year	26	13.7%
					1–3 years	48	25.1%
	Inventors/Technicians	41	21.5%		4–6 years	56	29.3%
	Researchers in intellectual property	16	8.4%		7–9 years	30	15.7%
	Other staff related to intellectual property	27	14.1%		More than 10 years	31	16.2%

Table 7
The model fit results of confirmatory factor analysis.

Model	χ^2/df	RMSEA	GFI	AGFI	CFI	NFI
M1	3.244	0.109	0.877	0.816	0.907	0.873
M2	2.331	0.084	0.913	0.867	0.946	0.911
M3	2.087	0.076	0.927	0.882	0.958	0.924

Note: M1 was a single-factor model, that was, IPS was assumed to be a single construct variable. M2 was a two-factor model, which combined COS and VBS into one factor. M3 was a three-factor model that assumed IPS had three independent constructs.

5.2.3. Validity assessment

Our validity assessment was comprised of three main aspects: construct validity, convergent validity, and discriminant validity. First, the model fit results presented in Table 7 indicated that nearly all of the fit indices met the relevant standards, providing evidence for the high construct validity of the scale. Second, the test of convergent validity relied on two indices: average variance extracted (AVE) and composite reliability (CR). For a scale to have high convergent validity, the AVE value should be greater than 0.5 and the CR value should be greater than 0.7. Fig. 3 and Table 8 showed that factor loadings of items, which fell between 0.67 and 0.82. Additionally, the AVE and CR value for each factor met the corresponding standards [39], further supporting the scale's acceptable convergent validity.

Third, the assessment of discriminant validity via comparing the value of the correlation coefficient with the square root of AVE value on the diagonal. Table 9 illustrated that the minimum value of the square root of AVE (0.712) was greater than the maximum value of the factor correlation (0.645), indicating acceptable discriminant validity for the scale [53]. Notable, each factor displayed both high correlation coefficients and high significance, further corroborating the findings of the exploratory factor analysis.

Based on the above analysis, the IPS scale, comprising 11 items developed in this study, effectively captured the three latent constructs and demonstrated acceptable reliability and validity.

6. Discussion

The increasing significance of intellectual property services (IPS) in driving scientific and technological innovation called for the conceptualization and quantification of a robust IPS scale. This study explored the structural dimensions and measurement items of IPS to develop and validate the IPS scale followed a standard process [42,61]. Using both qualitative and quantitative research methods, the IPS scale comprising 11 measurement items were constructed, encompassing three key dimensions: vocational skills services (VSS), commercial operation services (COS), and value-added business services (VBS). Through large-sample empirical studies, the scale was rigorously tested and refined, demonstrating favorable metric properties with high reliability and validity. The IPS scale served as a measurement instrument to assess the service quality and performance of VSS, COS and VBS offered by intellectual property service organizations throughout the entire process of creation, application, protection, and management of their clients' technical achievements. By providing a tool foundation for future research, this study contributed to better understanding the dynamics and development of IPS industry.

The first dimension of the IPS scale, VSS, refers to the basic and professional services of IPS, including agency services of writing

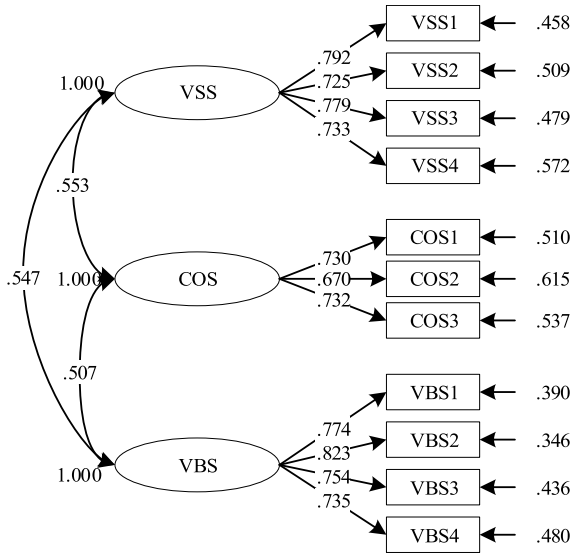

Fig. 3. The confirmatory factor analysis model of IPS.

Table 8
Results of the convergent validity test.

Variable	Factor	AVE	CR
IPS	VSS	0.574	0.843
	COS	0.506	0.754
	VBS	0.596	0.855

Table 9
Results of the discriminant validity test.

	Mean	SD	VSS	COS	VBS
VSS	4.373	0.505	0.758		
COS	4.257	0.560	0.645**	0.712	
VBS	4.244	0.486	0.581**	0.640**	0.772

Note: **$p < 0.01$, *$p < 0.1$, and the diagonal was the square root of the AVE.

intellectual property applications and maintaining intellectual property for clients, and legal services supporting in drafting contracts and engaging in lawsuits, as well as information services to conduct intellectual property novelty searches, technology tracking searches, competitors and potential partners searches, patent stability searches, and more. IPS providers with higher scores on the VSS dimension are more likely to create intellectual property application documents with clear technical features and comprehensive claim rights. This leads to reduce the ambiguity in technology, positively influencing the quality of the intellectual property [26,28]. Moreover, they are able to design the maximum protection scope and offer clients advice and measures in potential infringement cases, effectively avoiding infringement risks, ensuring the high stability of their intellectual property during subsequent use or litigation, and ultimately enhancing the legal effectiveness of intellectual property [62].

Regarding the second dimension, COS, mainly refers to intellectual property transfer services that supports the transfer and transformation of intellectual property, which included relationship matching services of identifying the potential partners for clients and facilitating commercial matchmaking, as well as business communication services of assisting clients in conducting commercial and price negotiations, and helping to mediate and resolve conflicts and differences between parties during technology transactions. As described in Table 2 and Appendix, commercial operation services includes transaction process services, which supports in formulating and submitting transaction agreements, and registering and recording intellectual property transfer contracts on behalf of clients. IPS providers with higher scores on the COS dimension indicate a greater ability to provide a broad social network and match suitable partners for both parties, effectively stimulating their willingness to cooperate and promoting the formation of collaborative relationships [25,27]. Additionally, they are equipped to offer rich information on technology, market, and law, which facilitates information exchange and sharing between parties, thereby reducing or even eliminating information asymmetry and improving the operational efficiency of the market economy [63,64].

In terms of the third dimension, VBS, represents high-end and personalized intellectual property application services of IPS, including consultation services to help clients with patent navigation, patent early warnings and strategic planning, and also including training services aimed at educating clients on basic knowledge, patent practices and management processes related to intellectual property. Furthermore, VBS encompasses assessment services that aid clients in evaluating the commercial value and market prospects of intellectual property. IPS providers with higher scores on the VBS dimension possess the ability to accurately assess the application prospects and commercial value of intellectual property. This reduces uncertainties in later application and industrialization phases, allowing them to develop reasonable intellectual property strategic planning for their clients [34,65]. Moreover, by offering training services to the public, IPS providers aim to promote and popularize basic and practical knowledge related to intellectual property to a wider audience, contributing to the high-quality development of the national economy and technology through intellectual property [66].

According to the holographic theory of the knowledge activity system [67], the service type in each sub-dimension not only serves its own primary function, but also to some extent, fulfills the roles of the other two sub-dimensions. This interconnectedness among the sub-dimensions implies that there is some degree of overlap and intersection in their roles throughout the entire chain of intellectual property. IPS, therefore, goes beyond being a mere extension of the creation, application, protection and management of intellectual property, but a vital link in the entire chain of intellectual property, providing essential support and serving as the foundation for the high-quality development of intellectual property.

7. Conclusion

Through a three-stage deductive-inductive study that combined qualitative and quantitative analysis, this study successfully developed and validated a systematic measurement scale of IPS. The IPS scale, comprising 11 items, was divided into 3 components: vocational skills services (4 items), commercial operation services (3 items), and value-added business services (4 items). Given the lack of attention towards the structural model and measuring tool of IPS, it may provide a theoretical and instrumental basis for future research upon IPS. Furthermore, the results and implications of this study could serve as a valuable indicator and reference for multi-subject to assess the overall service quality and development tendencies within IPS industry, so as to promote the advancement of IPS

industry in China.

7.1. Theoretical implications

The structural model of IPS and related scale developed in this study are expected to generate the following theoretical contributions. First, based on a review of existing literature, this study provided a comprehensive definition of IPS, filling a gap in the systematic interpretation of IPS's connotations. Second, through grounded theory, this study revealed the structural model and dimensions of IPS, which avoided a narrow focus on a single constitutive dimension, and provided a theoretical reference for intellectual property services agencies to diversify their service modes and expand their business scope. Meanwhile, the study validated the applicability of relevant theories in the context of intellectual property, contributing to providing new explanations for intellectual property services. Finally, the IPS scale was developed and the reliability and validity were empirically tested, addressing the existing lack of a measurement tool for IPS. The findings of this study expanded the measurement theory and models for IPS, and provided an operational measuring tool for future empirical research, which could be expected to promote the generation of more studies focusing on intellectual property services.

7.2. Practical implications

The IPS scale with 11 measurement items developed in this study could make valuable practical contributions to various stakeholders. First, government departments could assess and monitor the service quality and operational performances of IPS agencies based on the dimensions and scale of IPS. This would provide them with crucial insights into the development status and trends of IPS industry, facilitating better supervision and support for the sector, as well as the formulation of relevant policies, thereby enhancing the efficient growth of IPS industry. Second, the scale could serve as a useful tool for IPS agencies to evaluate and find deficiencies in service capabilities and operational modes, so that IPS agencies could tailor targeted incentive programs and optimize their management practices, leading to enhanced service delivery and client satisfaction. Finally, innovators or consumers could leverage the scale to refine their personalized needs and decisions. By aligning the scale with their technology at different stages of development, they could facilitate the creation of intellectual property rights with broad protection and high commercial value, and transform more intellectual properties into tangible productivity.

7.3. Limitations and future research

This paper presented a preliminary exploratory study on the dimensions and measurement of IPS, but it had several limitations. First, this study focused on a narrowly-defined concept of IPS, and mainly examined Chinese IPS agencies as the primary samples. While the grounded theory research provided valuable insights from the perspective of market-oriented IPS providers, it did not adequately include input from service recipients, which may lead to bias in the research results. Future studies could aim to include multiple subjects, such as governments, universities, research institutes, and scientific and technological enterprises, and examine the circumstances in other countries to validate and enhance the findings of this study. Second, the size and characteristics of the samples in this study were somewhat restricted due to resource limitations, which may lead to defects in the developed scale. Future studies could conduct larger and more extensive sample collection to enrich the measurement items and strengthen the robustness check of the scale. Third, while this study discussed the dimensions and scale of IPS, but it did not explore antecedents and consequences of IPS performance or the relationships between different types of intellectual property services. Future studies could delve into mediating and moderating mechanisms related to IPS performance, in order to provide further insights into the development of IPS industry. Finally, the model and scale developed in this study have not been practically applied and tested. Future studies should employ real data to test the methodology and model proposed in this study, ensuring the scale's broad applicability and reliability. This would establish a strong foundation for subsequent research endeavors, as well as provided valid and practical guidance for the continuous improvement in IPS quality and development of IPS industry.

Author contribution statement

Xiang Ma: Conceived and designed the experiments; Performed the experiments; Wrote the paper. Hua Jiang: Conceived and designed the experiments; Analyzed and interpreted the data. Shengbo Liu: Performed the experiments; Wrote the paper. Shiyu Zhang: Analyzed and interpreted the data.

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Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

Declaration of competing interest

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Appendix

The results of open coding

Example of original data statements	Initial concepts	Initial categories
… Before we write a patent document, we need to analyze it, carry out all kinds of patent searches and strategies, and finally give you a writing plan …	A1. Documents writing (21)	B1. Intellectual property application
… Our company requires a 100% reply, and no one is allowed to withdraw. Even if the intellectual property owner does not reply, we will help him to reply …	A2. Replies to comments (11)	
… In the early stages, many agencies did not even conclude the application documents, but submitted the application to the China National Intellectual Property Administration after proofreading and typesetting. In fact, it was a transactional agent that delivered documents …	A3. Submission of applications (9)	
… We have a special department responsible for foreign applications, called the foreign department. The foreign department is divided into trademark, patent, copyright and other business, mainly to assist some overseas applications …	A4. Foreign applications (12)	
… Generally, we will not finish the intellectual property application document independently at the beginning. We usually need to communicate with technicians repeatedly, such as communicating about technical aspects, and finally work out a compromise to apply for the intellectual property …	A5. Communication with inventors (18)	B2. Contacts and communication
… We remind clients to pay the annual intellectual property fees every year. If the client does not instruct us to pay this year, we will not pay it for him …	A6. Remind of annual fees (8)	
… The universities are usually not the subject of the implementation of the patent. They have the technology and intellectual property rights, but when the intellectual property rights are infringed, they rarely initiate lawsuits. We [IPS agencies] can help them protect their rights through infringement lawsuits, and usually train them to protect their rights [awareness].	A7. Infringement lawsuits (20)	B3. Lawsuits
… Invalid [lawsuits] cases are involved in the daily intellectual property services process, and our agents will also participate in some invalid lawsuits work, such as invalid replies, invalid requests, invalid declarations and so on …	A8. Invalid lawsuits (16)	
… IPS agencies are better at contracting than the applicants, such as the legal aspects of writing and reviewing contracts involving intellectual property …	A9. Formulation of intellectual property contracts (9)	B4. Drafting of contracts
… When we get a technical disclosure letter, we will run a search to see if anyone else has applied for it or if it has been published in other documents …	A10. Retrieval for existing technology (12)	B5. Intellectual property information retrieval
… He [inventor] just thought of a material. Through our search, we found that all the materials of this group may be used in such experiments, so we suggested he apply for the patent for this group at the same time, instead of only applying for this one material …	A11. Retrieval for peripheral patents (16)	
… After the discussion, we found the innovation point, and then explored further. Maybe we found that the technical disclosure materials he wrote were not the core technology he wanted to protect. Maybe it was what he didn't write that he wanted to protect, which was his real innovation point …	A12. Secondary innovation (12)	
… It is necessary for us to conduct patent searches before writing patent applications as an agent. The search of patentability is a necessary process for us …	A13. Search of patentability (16)	B6. Legal information retrieval
… Related work such as the monitoring and analysis of intellectual property legal status is a routine part of our information services …	A14. Search of legal status (7)	
… We maintain long-term cooperation with many universities and professors, and our services have penetrated into every laboratory of our clients …	A15. Relationships with universities (13)	B7. Network of relationships

(*continued on next page*)

(*continued*)

Example of original data statements	Initial concepts	Initial categories
… We have long-term relationships with many companies both at home and abroad. For example, many of our clients are companies with a certain scale in the UK, including [or even] companies with a certain scale in Europe …	A16. Relationships with enterprises (18)	
… We have a lot of resources, such as contact with accounting firms, information companies, patent agencies and so on …	A17. Relationships with other agencies (15)	
… We applied this technology of toxicants to the field of medical testing, which was completely cross-industry. The two trading partners did not know each other before, but we did a lot of matchmaking work to help them establish contact …	A18. Commercial matchmaking (22)	B8. Ability to match supply and demand
In some cases, the academic has found a buyer, but he [academic] is not clear about how to negotiate, including how to avoid risks, how to make a patent portfolio, how to deal. So many teachers need us [IPS agencies] to provide some support for the negotiation process …	A19. Negotiation skills (25)	B9. Negotiation ability
… Some teachers set their own price too high. The enterprise is only willing to pay 100,000 yuan, but the teacher's price is 1 million yuan in his mind. In this case, we [IPS agencies] can help each side reach their own balance point, such as charging both the process and the result of the implementation of the patents …	A20. Price consultation (15)	
… Technology transfer is a special test for the management consciousness of the leaders of the IPS agencies. There should be a solution to coordinate this group of people. Talents from various fields should be gathered every month and every quarter to have a chat and think about the future work …	A21. Management coordination (17)	B10. Coordinate ability
… Sometimes, the work related to technology transfer is actually writing a contract, and more often reviewing a transaction contract …	A22. Review of transaction contracts (15)	B11. Transaction materials processing
… Assisting transferors or assignees to draft some cooperation agreements, such as whether to choose licensing, assignment, or other means of technology transfer for the transaction …	A23. Formulation of transaction agreements (19)	
… In terms of technology transfer and actual operation, the involvement of [intellectual property] services agencies are definitely required to submit licensing agreements or project changes to China National Intellectual Property Administration …	A24. Filing of transaction contracts (14)	
… The whole transaction process, including the whole services process, is all in our internal control system. In particular, some services agencies are using online systems that make the transaction process more transparent and observable, and provide a function of supervising the performance of contracts …	A25. Supervise the performance of contracts (12)	B12. Supervision of transactions process
… Perhaps a dozen or two dozen patents were laid out before the project began. We were involved in how to write these patents, when to apply for them, and how to arrange them to form a patent network …	A26. Patent portfolios (21)	B13. Professional consulting business
… Before the project was launched, we [IPS agencies and inventors] worked together using patent navigation to determine where the project could be further studied and which aspects could not be patented, so as to avoid useless work …	A27. Patent navigation (18)	
… By searching and analyzing the legal status and other information of patents, IPS agencies can know which patents are liable to be infringed and prosecuted, so as to assist clients in early warning work …	A28. Patent early warning (23)	
The services whereby we provide enterprises with support in strategy and planning are similar to management consultancy, also known as operational consultancy …	A29. Strategic planning (16)	B14. Managerial consulting business
… Before the inventors start the projects, the agents can do some searching and consulting, so as to give inventors a deeper understanding of the market and development status of technology …	A30. Project approval (14)	
… We have corresponding training courses every week, and each department is required to set up a training course to explain what your department's business is, so that everyone can understand what your strengths are and what you do, and popularize them to every staff member …	A31. Business capacity training (16)	B15. Intellectual property business training
… IPS agencies can provide consultations and trainings for clients to establish a scientific, systematic, and standardized IPR management process system, and guide the orderly operation of the system …	A32. Management process training (14)	
… Before intellectual property application, inventors need to have basic training, for example, the technicians are not very familiar with the intellectual property law. We will conduct a (basic knowledge) training in the early stage …	A33. Basic knowledge training (21)	B16. Intellectual property knowledge training
… Our lectures are the reminders to universities academics. Our lectures can create awareness of technology transfer in teachers who previously had no awareness of it, or increase their awareness, which is the role that training can play …	A34. Ideological training (14)	
… We also do intellectual property valuation, which is based on several mathematical formulas. Most of them are calculated in terms of costs, R&D costs, patent application costs, maintenance costs, and various human and financial inputs …	A35. Intellectual property value assessment (25)	B17. Comprehensive assessment
… We evaluate the commercial value of intellectual property before technology transfer, and that's one of the things we're doing right now, doing commercial value analysis for many universities and judging the commercial prospects of these technologies …	A36. Market prospect assessment (20)	
… The technology should be evaluated. How can investors know that this technology has high application potential in the future …	A37. Application potential assessment (16)	

Note: The number in parentheses after each initial concept represented the number of original data statements that repeated the concept or had a similar meaning.

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