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Does intellectual property protection stimulate digital economy development?

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ABSTRACT

The digital economy plays an important role in society and the economy. However, we know little about what factors affect the development of the digital economy. Using a self-developed index for measuring Chinese provincial-level digital economy development, this paper examines the impact of intellectual property protection on the digital economy. We find that there is a U-shaped relationship between intellectual property protection and digital economy. Our findings remain valid after a battery of robustness tests. Our findings support the importance of intellectual property protection in developing the digital economy.

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KEYWORDS

Digital economy; intellectual property protection; U-shaped relationship

1. Introduction

The digital economy based on information and communication technology (ICT) has significantly changed everything from daily living to the operation of the economy (Brynjolfsson & Collis, 2019; Teece, 2018). Information infrastructure enables the widespread dissemination of information technology and promotes the digital economy. The rise of Chinese digital giants, such as Tencent and Alibaba shows that China has become one of the core leaders of the global digital economy. According to the China Internet Network Information Center, the scale of the Chinese digital economy has reached 31.3 trillion yuan in 2019, accounting for 34.8% of GDP.

As the foundation of digital economy (Watanabe, Naveed, Tou, & Neittaanmäki, 2018), ICT is at the center of much innovation over the past fifty years (Forman & Goldfarb, 2020). However, the value-capture problem for innovators in the digital economy involves many challenges (Teece, 2018), affecting the development of digital economy. Thus, the intellectual property protection problem in the digital economy is serious (Lerner, 2009). According to the literature, the evidence of the impact of intellectual property protection on innovation is mixed (Fang, Lerner, & Wu, 2017; Gangopadhyay & Mondal, 2012; Lerner, 2009). Weaker intellectual property protection can increase knowledge spillover and contribute to the common pool of knowledge (Gangopadhyay & Mondal, 2012; Rockett, 2010). Inventors can learn and develop digital innovation by reverse engineering and imitating successful digital products, which promotes the development of the digital economy. However, unlike

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routine production activities that follow conventional technology and obtain quick returns, innovation is a long-term, risky, and idiosyncratic process (Holmstrom, 1989). Intellectual property protection provides inventors with an exclusionary right that inventors can use to obtain the marginal benefit of innovation. Intellectual property infringement enables rivals to copy innovation without having to bear related innovative costs, which diminishes inventors' incentives to invest in innovation (Smith & Mann, 2004). Thus, the tension between these two forces will determine the effect of intellectual property protection on the digital economy.

Although discussion of intellectual property protection usually focuses on the national level, it also presents spatial differences at the sub-national level (Ang et al., 2014; Fang et al., 2017; Gao, 2021; Schotter & Teagarden, 2014). After China's economic reforms in 1978, China worked on building a modern intellectual property system. The laws of intellectual property protection are consistent with international standards and are the same across China. However, in practice, intellectual property protection in China has a poor record, with significant variations in enforcement and interpretation of intellectual property protection laws across different regions (Ang et al., 2014; Fang et al., 2017; Schotter & Teagarden, 2014). These variations in intellectual property protection provide an excellent setting for this empirical study.

Using the data of the provinces in China for the 2012–2018 period, we develop a provincial digital economy index and examine the impact of intellectual property protection on the development of the digital economy. We provide extensive evidence that the relationship between intellectual property protection and the development of digital economy is U-shaped.

This paper contributes to the literature in the following ways. First, we empirically examine the impact of intellectual property protection on the digital economy, addressing gaps in the literature. Previous studies focus on the measures of the digital economy (García-Herrero & Xu, 2018) and the effects of the digital economy (Dean, 2018). We study the factors that shape the digital economy. Second, we enrich the literature on intellectual property protection (Fang et al., 2017; Gangopadhyay & Mondal, 2012; Lerner, 2009). Previous studies have largely explored the impact of intellectual property protection at the micro level, such as corporate innovation (Fang et al., 2017) and firm debt costs (Alimov, 2019). This paper empirically finds that intellectual property protection also has macro effects, affecting the development of the digital economy.

2. Sample and empirical methodology

2.1. Sample

To construct our sample, we start with all 31 Chinese provinces during 2012–2018, using the Regional Statistical Yearbook of China and the Wind database. The data on intellectual property protection is collected from the Peking University law database. The data on the number of patents for measuring digital technology innovation is collected from WIPO, which publishes the international patent applications of Chinese firms. Missing information on province-years is hand collected from the statistical bulletin of each

province. Our final sample includes 217 province-year observations representing 31 provinces. To mitigate the effect of outliers, we also winsorize the continuous variables at the 1% and 99% levels.

2.2. Measure of intellectual property protection

There is no uniform way to measure intellectual property protection. Previous studies have generally developed an index of intellectual property protection (Fang et al., 2017; Sweet & Maggio, 2015). Considering the availability of data, we use the natural logarithm of one plus the number of the first instance of intellectual property disputes in each province to measure intellectual property protection (*IPR*), because the legal system of China is under-developed (Allen, Qian, & Qian, 2005) and the number of intellectual property disputes in court can reflect the support for intellectual property protection from the legal system. A higher value for *IPR* means stronger intellectual property protection.

2.3. The measure of digital economy

Scholars have developed several different indexes to measure the digital economy. The most authoritative include the index systems proposed by the Organization for Economic Co-operation and Development (OECD) and the U.S. Bureau of Economic Analysis (BEA). The OECD index describes the development of digital economy using four dimensions: investing in smart infrastructure, empowering society, unleashing creativity and innovation, and delivering growth and jobs (Colecchia et al., 2014). The BEA measures the development of digital economy in three dimensions: digital-enabling infrastructure, e-commerce, and digital media (Barefoot, Curtis, Jolliff, Nicholson, & Omohundro, 2018). Mueller et al. (2017) used the market capitalization of firms belonging to the digital economy sector to analyze the digital economy development of the USA, Germany, the Republic of Korea, and Sweden. Based on the above literature, we integrate the international mainstream indexes to develop a new index for measuring the development of China's provincial digital economy. Table 1 shows the new index. Based on the availability of provincial data in China, the index describes the development of the digital economy using six dimensions: digital infrastructure construction level, digitalization

Table 1. Measuring the development level of the digital economy.

First level indicators	Second level indicators
Digital infrastructure construction level	Telecommunications services Mobile phone penetration
Digitalization level of the society advanced by ICT	Number of domains Number of websites Number of web pages
Digital technology innovation capability	The number of patent applications for four technologies: artificial intelligence, blockchain, cloud computing and big data.
Economic growth promoted by ICT	Total investment in fixed assets of information transmission, computer services and software industry, revenue from software business
Development level of emerging digital economy industries	The number of enterprises with e-commerce transactions, e-commerce sales, e-commerce purchases
Capitalization level of digital economy enterprises	Market capitalization of listed digital technology companies

level of the society advanced by ICT, digital technology innovation capability, economic growth promoted by ICT, development level of emerging digital economy industries, and the capitalization level of digital economy enterprises.

We then use the CRITIC methodology to give weights to these indicators because the method is an objective method that avoids the randomness created by subjective weightings yet considers the variability and correlation of indicators (Yalçın & Ünlü, 2018). The weights are given by the following equation.

$$W_i = C_i / \sum_j^n C_j, i = 1, 2, \dots, n \quad (1)$$

$$C_i = \delta_i \sum_j^n (1 - R_{ij}), i = 1, 2, \dots, n, i \neq j \quad (2)$$

Where δ_i represents the standard deviation of the indicator i and R_{ij} represents the correlation coefficient between indicator i and indicator j . Based on the above processing, the resulting composite index value constitutes the final index (*Digital*) and is used in this paper to measure the level of digital development for each province.

2.4. Empirical model

To investigate the impact of intellectual property protection on digital economy, we establish the following model.

$$Digital_{i,t} = \beta_0 + \beta_1 IPR_{i,t} + \beta_2 IPR_{i,t}^2 + \gamma Control_{i,t} + \mu_i + \nu_t + \varepsilon_{i,t} \quad (3)$$

Where i and t represent province and year, respectively. *Control* represents control variables that might affect digital economy, including the level of economic development (AGDP), government R&D fund (*Fund*), human resources (*Human*), the industrial structure (*Structure*), and government expenditure (*Govern*). The coefficients of interest are β_1 and β_2 . We also include province fixed effect (μ_i) to control for unobservable time-invariant province-specific characteristics and year-fixed effects (ν_t) to control for common time trends. All variables are defined in [Appendix A](#).

Table 2. Descriptive statistics.

Variable	N	Mean	Std	Min	Median	Max
Digital	217	1.8702	0.7859	0.6918	1.7046	3.9199
IPR	217	6.1046	2.1518	0.0000	6.3456	9.6101
AGDP	217	10.8013	0.4115	10.0076	10.7066	11.7675
Fund	217	0.4523	0.2619	0.1684	0.3643	1.2864
Human	217	1.9150	0.4998	0.8497	1.8559	3.3553
Structure	217	1.1903	0.6290	0.5985	1.0201	4.1653
Govern	217	0.2834	0.2085	0.1208	0.2296	1.2914

3. Empirical result

3.1. Descriptive statistics

Table 2 represents the summary statistics on variables used in our analysis. The minimum and maximum values of *IPR* are 0.0000 and 9.6101, respectively, showing intellectual property protection has greater heterogeneity across different regions (Ang et al., 2014; Fang et al., 2017). Further, there is an obvious gap in the level of digital economy development. The median and maximum value of *Digital* are 1.8702 and 3.9199, respectively. This is consistent with the fact that the development of digital economy varies across regions within countries. For example, eastern China hosts numerous digital giants, such as Baidu, Alibaba, Tencent, and Tik Tok.

3.2. Empirical regression

Column 1 of Table 3 reports the estimate of the regression model (3). The coefficients of *IPR* are significantly negative while the coefficient of IPR^2 is significantly positive, suggesting that the relationship between *IPR* and *Digital* is U-shaped. Initially, intellectual property protection stifles the development of digital economy because intellectual property hinders knowledge spillover to other inventors. However, as it develops, innovations in digital technology require more inputs, meaning that inventors face higher innovation costs. Stronger intellectual protection provides inventors with an exclusionary right, enabling them to obtain the marginal benefit of innovation, which stimulates inventor engagement in digital innovation and is conducive to the

Table 3. The impact of intellectual property protection on digital economy development

	(1)	(2)	(3)
	Digital _t	Digital _{t+1}	Digital _t
<i>IPR</i> _t	−0.1571*** (0.0222)	−0.1188*** (0.0226)	−0.2061*** (0.0250)
IPR^2_t	0.0162*** (0.0020)	0.0148*** (0.0021)	0.0219*** (0.0022)
<i>AGDP</i> _t	0.3182** (0.1439)	0.6123*** (0.1762)	0.3226** (0.1488)
<i>Fund</i> _t	0.3751*** (0.0962)	0.2294** (0.1032)	0.3320*** (0.0868)
<i>Human</i> _t	0.4668*** (0.0992)	0.4698*** (0.1175)	0.5069*** (0.0910)
<i>Structure</i> _t	0.1539** (0.0720)	0.0583 (0.0805)	0.1257** (0.0609)
<i>Govern</i> _t	0.0292 (0.6184)	0.577 (0.7029)	0.2424 (0.6118)
Constant	−2.8376* (1.6901)	−5.9267*** (2.0218)	−2.8884 (1.9413)
Province fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
<i>N</i>	217	186	217
<i>R</i> ²	0.904	0.882	0.985
Cragg-Donald Wald <i>F</i> statistic	–	–	119.742
Kleibergen-Papp <i>rk LM</i> statistic	–	–	49.727

This table reports the empirical results. In column 1, we examine the impact of intellectual property protection on the digital economy. In column 2, we consider that digital technologies need time to be applied and use the digital economy at $t + 1$ as the dependent variable. In column 3, we account for possible endogeneity. The standard errors are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

development of the digital economy. Further, the threshold value of intellectual property protection is 4.7190. Meanwhile, the mean value of intellectual property protection is 6.1046, which shows that continuing to improve the level of patent judicial protection is conducive to the development of the digital economy for most provinces in the current stage.

In column 2 of Table 3, we use the digital economy at $t + 1$ as the dependent variable, considering that digital technologies may require time to be applied. The findings of this paper may suffer from reverse causation because the digital economy based on IT technological innovation may change the demand for intellectual property protection. In column 3 of Table 3, we use the intellectual property protection in other provinces in the same year as an instrumental variable and use two-stage least squares (2SLS) to examine the effect of intellectual property protection on the digital economy. The values for the Cragg-Donald Wald F and Kleibergen-Papp rk LM statistic are 119.472 and 49.727, respectively, suggesting that the collection of instrumental variables is reasonable. In sum, we find that the U-shaped relationship described above remains valid.

4. Conclusion

As the digital economy becomes a new engine of economic growth, the problem of stimulating its development is attracting greater attention. This paper provides novel and important evidence showing that the impact of intellectual property protection on digital economy is U-shaped. Our findings remain robust after using an alternative identification method and using an instrumental variable to control for potential endogeneity. Given that the digital economy plays an important role in society and the economy, our findings should be of interest for both scholars and policymakers. To promote development, the government should consider adopting appropriate intellectual property protection strategies. For China in its present stage of development, the government should strengthen intellectual property protection.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix A

Table A1. Variable definitions.

<i>IPR</i>	The natural logarithm of one plus the number of first instance of intellectual property disputes in court
<i>Digital</i>	The nature logarithm of the index of digital economy that is calculated in the section 2.3
<i>AGDP</i>	The nature logarithm of per capital gross domestic product
<i>Fund</i>	100×(Government technology Expenditure/ gross domestic product)
<i>Human</i>	100×(The number of college students/total population)
<i>Structure</i>	The gross product of the third industry/ the gross product of the second industry
<i>Govern</i>	Government expenditure divided by gross domestic product