Applied Economics Letters

ISSN: 1350-4851 (Print) 1466-4291 (Online) Journal homepage: www.tandfonline.com/journals/rael20

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To cite this article: Hao Xu & Shaoqing Huang (30 May 2025): The effect of broadband infrastructure on firm patent transactions: evidence from the "Broadband China" Strategy in China, Applied Economics Letters, DOI: 10.1080/13504851.2025.2513974

To link to this article: https://doi.org/10.1080/13504851.2025.2513974

APPLIED ECONOMICS LETTERS
https://doi.org/10.1080/13504851.2025.2513974

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The effect of broadband infrastructure on firm patent transactions: evidence from the "Broadband China" Strategy in China

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ABSTRACT

An effective patent transaction market can enhance the efficiency of the innovation system, playing a critical role in new idea allocation and technology diffusion. However, frictions in the technology market hinder patent transactions. Therefore, this paper investigates whether the enhanced information accessibility resulting from broadband infrastructure can promote firm patent transactions by utilizing the staggered rollout of China's Broadband China Strategy (BCS) across cities as an exogenous shock. Using newly constructed firm-level patent transaction data and the difference-in-differences (DID) approach, we find that BCS increases firm patent transactions by 7.6%. Our results still hold after a series of robustness checks. Our mechanism analysis indicates that the expansion of patent transaction networks and firm digital transformation are the channels through which broadband infrastructure promotes firm patent transactions. The heterogeneity analysis reveals that BCS has stronger impacts on patent transactions for high-tech and large firms, as well as for firms located in regions with better intellectual property rights protection.

KEYWORDS

Broadband infrastructure; internet; patent transaction; patent

JEL CLASSIFICATION

L86; O33; O34

I. Introduction

Technological innovation enhances firm market competitiveness and productivity, playing a critical role in firm development and macroeconomic growth (Romer 1990; Rubera and Kirca 2012). However, due to high risks, failed innovations may incur substantial losses or missed market opportunities. Acquiring technology externally via patent markets expands decision-making options (Arora, Fosfuri, and Gambardella 2001), facilitating technology diffusion and firm innovation (Arqué-Castells and Spulber 2022). Nevertheless, frictions arising from search costs and information asymmetries significantly undermine the efficiency of technology markets (Akcigit, Celik, and Greenwood 2016; Zhang 2021).

Existing studies suggest that internet can reduce transaction costs (Czernich et al. 2011; Litan and Rivlin 2001). Broadband mitigates spatial and temporal constraints on information transmission, thus reducing search costs (Goldfarb and Tucker 2019; Orlov 2011). Furthermore, high-speed internet enables firms to communicate and negotiate via video conferencing, enhancing information accessibility and transparency, thereby alleviating information asymmetries (Li, Li, and Yang 2022). Therefore, broadband may reduce information frictions in technology markets, lower transaction costs, and facilitate firm patent transactions.

While the internet's economic impact is well studied, its effect on firm patent transactions remains underexplored. This paper exploits China's Broadband China Strategy (BCS) as an exogenous shock to analyse how broadband-driven information accessibility promotes firm patent transactions.[1]

Using novel firm-level patent transaction data and a difference-in-differences (DID) approach, we find broadband infrastructure significantly enhances firm patent transactions by expanding transaction networks and facilitating digital transformation, with stronger effects for high-tech firms, large firms, and firms in regions with strong intellectual property rights (IPR) protection.

This paper contributes to the literature on the internet's economic consequences, which mainly

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[1]See Appendix B for the institutional background of BCS.

Supplemental data for this article can be accessed online at https://doi.org/10.1080/13504851.2025.2513974

examines its effects on economic growth (Czernich et al. 2011), trade (Malgouyres, Mayer, and Mazet-Sonilhac 2021), innovation (Yang, Zheng, and Zhou 2022), and knowledge diffusion (Huang, Hou, and Wang 2023). We demonstrate the effect of broadband on patent transactions, extending the literature on the internet's economic consequences.

We also contribute to the literature on technology markets. While prior studies focus on transport infrastructure facilitating face-to-face communication to reduce information asymmetry (Andersson, Berger, and Prawitz 2023; Wu and Yang 2023), we emphasize broadband's capacity to improve information accessibility without physical interactions. Cai et al. (2024) examines how increased technology demand from e-commerce demonstration zones affects city-level patent transfers. In contrast, we examine how broadband-driven improvements in information access raise technology market efficiency and shape firm patent transactions. Moreover, using firm-level patent transaction data allows us to explore heterogeneous effects across firm types. This study deepens the understanding of broadband infrastructure's impact on the technology market.

II. Data and empirical strategy

Data

Our dependent variable is firm-level patent transaction counts, derived from CNIPA data (1985--2019) based on legal events and contract effective dates, excluding name-change and intra-group transactions.[2]

Firm data are from CSMAR and CNRDS, focusing on A-share listed manufacturing firms. After matching financial and patent transaction data by firm names and years, excluding samples with missing key variables and ST/*ST firms, we obtained an unbalanced panel dataset of 22,915 firm-year observations for 2,655 firms from 2003 to 2019.

City-level socioeconomic data are from the China City Statistical Yearbook, the statistical yearbooks of each city, and the CEIC database. BCS pilot city data are from the Ministry of Industry and Information Technology of China.

Empirical strategy

By utilizing the step-by-step rollout of BCS, we employ the following staggered DID specification to identify the causal effect of BCS on firm patent transactions:

$$Y_{ict} = \alpha + \beta BCS_{ct} + X_{ict}^{'}\gamma + Z_{ct}^{'}\theta + \mu_t + \delta_i + \varepsilon_{ict}, \quad (1)$$

where Y_{ict} represents the outcome variable of patent transactions of firm i located in city c in year t, measured by the logarithm of the number of patent transactions plus 1; BCS_{ct} is a dummy variable equal to 1 if city c implements BCS in year t; $X_{ict}^{'}$ and $Z_{ct}^{'}$ are vectors containing a set of firm- and city-level control variables. μ_t and δ_i are year

Table 1. The definitions and descriptive statistics for the variables.

Variable name	Definition	N	Mean	S.D.
lnPatentTransaction	The logarithm of the number of patent transactions plus one	22915	0.507	1.005
BCS	Whether city *c* is a pilot city for the BCS in year *t*	22915	0.332	0.471
Size	The logarithm of total assets	22915	21.666	1.235
Age	The logarithm of the firm's age plus one	22915	2.691	0.409
Lev	The ratio of the firm's total liabilities to total assets	22915	0.456	1.127
Cash	The ratio of the firm's net cash generated from operating activities to total assets	22915	0.047	0.111
ROA	The ratio of the net profit to total assets	22915	0.037	0.841
Patent	The logarithm of the number of patents granted to the firm in the year plus one	22915	2.097	1.627
GDP	The logarithm of GDP	22915	17.586	1.201
Population	The logarithm of the total population	22915	6.329	0.662
S&T expenditure	The logarithm of science and technology expenditures	22915	11.847	2.099
Education expenditure	The logarithm of education expenditures	22915	13.628	1.571
Fiscal pressure	The ratio of fiscal expenditure to fiscal revenue	22915	1.601	1.014
Structure	The ratio of output in the secondary sector to output in the tertiary sector	22915	1.055	0.506

[2]Including both sales and purchases.

Table 2. The effect of BCS on firm patent transactions.

	lnPatentTransaction		
	(1)	(2)	(3)
BCS	0.094**	0.089**	0.076**
	(0.047)	(0.041)	(0.038)
Firm-level control variables	No	Yes	Yes
City-level control variables	No	No	Yes
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	22915	22915	22915
R^2	0.397	0.421	0.422

***denotes significance at the 1% level, **denotes significance at the 5% level, and * denotes significance at the 10% level. Robust standard errors clustered at the city level are shown in parentheses.

and firm fixed effects, respectively. ε_{ict} is the random error term, clustered at the city level. Variable definitions and descriptive statistics are detailed in Table 1.

III. Empirical results

Baseline results

Table 2 presents the baseline results from the staggered DID method, showing that BCS significantly increases firm patent transactions by 7.6% after including all control variables and fixed effects. In comparison, Wu and Yang (2023) find high-speed rail increases city patent transactions by approximately 6% based on OLS estimates, and by about 17% using Poisson regression. Given that the mean of our dependent variable is roughly four times larger than in Wu and Yang (2023) (4.7 vs. 1.1 in raw counts), the effect of BCS is both statistically significant and economically meaningful in relative terms.

Robustness test

Appendix C reports robustness tests confirming our findings remain valid under various alternative specifications.

IV. Mechanisms analysis

Expansion of firms' patent transaction networks

Search costs and information asymmetries in technology markets hinder firms from identifying suitable transaction partners (Hellmann 2007; Zuniga and Guellec 2009). We first test whether broadband reduces such barriers. To capture partner diversity, we construct a diversity index based on the Herfindahl-Hirschman Index:

$$Diversity_{it} = 1 - \underbrace{\sum_{j \in J} \left(\frac{X_{ijt}}{X_{it}} \right)^2}_{HHI_{it}} \tag{2}$$

where X_{ijt} is the number of patent transactions between firm i and partner j in year t, and X_{it} is the total transactions of firm i in year t. The index ranges from 0 to 1.[3]

Table 3. The effect of BCS on firms' patent transaction partners.

	lnTransactionPartner	Diversity
	(1)	(2)
BCS	0.036*	0.045***
	(0.018)	(0.015)
Control variables	Yes	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	22915	6407
R^2	0.403	0.462

Same as Table 2.

Table 3 shows that BCS significantly increases both partner count and diversity index, suggesting that broadband expands firms' patent transaction networks, implying the alleviation of impediments in patent transactions.

Promoting firms' digitalization

Digital technology can enhance firms' information collection and processing ability, which can help firms quickly track new inventions (Wang and Cheung 2011) and reduce search costs and

[3]The diversity index is not defined for firm i in year t if no patent transactions are recorded.

Table 4. The effect of BCS on firm digitization.

	Digitization (word frequency)	IT investment
	(1)	(2)
BCS	0.103**	3.200**
	(0.047)	(1.334)
Control variables	Yes	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	22915	22915
R^2	0.733	0.648

Same as Table 2.

information asymmetry (Niu et al. 2023). Existing studies show that digitalization significantly facilitates technology transfer (Zhu et al. 2025). Therefore, we examine whether BCS promotes firm digitalization. Digitalization is measured by: (1) the log frequency of digitalization-related terms in annual reports and (2) the proportion of IT investment (measured by the net value of software, office electronics, and self-service equipment) relative to net total assets.

Table 4 shows that BCS increases digitalization-related word frequency by 10.3% and IT investment share by 3.2 percentage points, indicating significant promotion of firm digitalization.

V. Heterogeneity analysis

High-tech firms or not

Firms at the technological frontier, especially high-tech firms, have a greater demand for new technologies (Arora et al. 2024) and greater sensitivity to information access.

We categorize firms as high-tech if their citation-weighted patents exceed the median. The results in column 1 of Table A1 show that BCS has a greater effect on high-tech firms.

Firm scale

We next explore whether BCS effects differ by firm size, classifying firms as large if their total assets exceed the median. The results in column 2 of Table A1 show that BCS has a stronger impact on patent transactions for large-scale firms.

Level of IPR protection

IPR protection reduces transaction costs, enabling firms to better leverage patent values (Bessy and Brousseau 1998). Using a city-level IPR protection index constructed following the methodology of Shen and Huang (2019), column 3 of Table A1 shows a significantly greater effect of BCS in cities with stronger IPR protection.

VI. Conclusion

This paper investigates the causal impact of broadband infrastructure on firm patent transactions using a DID approach based on China's BCS rollout. Combining CNIPA and firm-level data, we find BCS significantly boosts patent transactions by expanding patent transaction networks and enhancing firm digitalization. The effect is stronger among high-tech firms, large firms, and regions with stronger IPR protection.

Based on our findings, we offer the following policy recommendations. First, prioritize broadband expansion in regions where high-tech firms are concentrated to enhance service quality and computing capacity. Second, connectivity should be accompanied by stronger local IPR enforcement, such as IP courts and expedited patent examination, to sustain trading incentives. Third, broadband use in patent transactions should be integrated with digital technologies and online trading systems.

While our identification strategy leverages the staggered rollout of BCS – a context-specific policy – the finding that broadband facilitates patent transactions by improving information accessibility is applicable to other developing economies facing similar frictions. However, institutional differences, particularly in IPR protection, may affect the generalizability of our findings.

Author contributions

CRediT: **Hao Xu:** Conceptualization, Data curation, Formal analysis, Methodology, Software, Validation, Visualization, Writing – original draft; **Shaoqing Huang:** Conceptualization, Supervision, Writing – review & editing.

Disclosure statement

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

Funding

Shaoqing Huang would like to acknowledge financial support from the National Social Science Fund of China [project number: 22AZD036] and the National Natural Science Foundation of China [project number: 71973096].

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