Trade protection and firm innovation in China

Tao Huang
School of Finance and Trade, Liaoning University, Shenyang, China

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Abstract

Purpose – The author investigates the effect of trade protection on domestic firm innovation in China and explores the channel through which trade protection affects corporate innovation.

Design/methodology/approach – Using a sample of Chinese A-share manufacturing companies from 2003 to 2019, the author starts with a univariate analysis by examining the innovation output after trade protection for all samples. The author uses the natural logarithm of one plus the number of trade protection cases received by the industry to which the firm belongs in a particular year to proxy for trade protection.

Findings – The author finds that trade protection significantly encourages firms' patent application, particularly substantive patents, which is stronger in non-state-owned enterprises. Moreover, the mitigation of financial constraint is plausible channel that allows trade protection to promote innovation.

Practical implications – For practitioners, they should seize the dividends of national policies. In the process of implementing trade protection, they should concentrate on improving their innovation level and enhancing their core competitiveness. When they are not subject to trade protection, they can also make profits and develop in the long run.

Social implications – For policy makers, in the early stage of industry development, trade protection can be used to ease the companies' financing constraints and improve the companies' profits, which will help them concentrate their efforts, promote innovation and further develop. However, in the mid-term development of the industry, policy makers should reduce trade protection. Through the entry of foreign capital, companies face increased competition, which can enhance the companies' motivation for long-term development.

Originality/value – Overall, this paper sheds light on the real effects of trade protection and the determinants of innovation. First, the paper sheds light on the impact of international trade on firms' innovation. Second, this study also contributes to the emerging literature on the effect of trade policy uncertainty on financial constraint. Third, the paper adds to the stream of literature on the drivers of innovation.

Keywords Trade protection, Innovation, Financial constraint

Paper type Research paper

1. Introduction

Previous studies show that trade protection has a profound effect on corporate behavior, such as markup (Konings and Vandenbussche, 2005), technology gaps (Crowley, 2006), productivity (Konings and Vandenbussche, 2008), price-cost margins (Rovegno, 2013), firm decisions to enter and exit (Crowley *et al.*, 2018) and so on. However, as an important feature of the corporate, it is widely identified that innovation has always been considered vital for a country's productivity growth and hence the growth of its economy (Moshirian *et al.*, 2021). Quite surprisingly, no empirical research has explored the effect of trade protection on firm innovation, and in this paper, I attempt to fill this gap by examining the relationship between trade protection and firm innovation.

In this paper, I investigate the relationship between trade protection and firm innovation in China, and the reasons are as follows. First, trade protection is an important trade tool, but there has been few studies researched its impact on the strategic decision of domestic firms. Therefore, it is of great theoretical and practical significance to study the relationship between trade protection and firm innovation. The second is because of the importance of innovation. Among the elements of a firm's performance, innovation is a key driver of a nation's competitiveness and long-term economic growth (Solow, 1957; Porter, 1992).

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The trade environment faced by the enterprises has great significance in their strategic decision. Therefore, it is necessary to study the relationship between trade protection and corporate innovation.

Based on the data of all A-share manufacturing companies listed on the Shanghai and Shenzhen Exchanges from 2003 to 2019, I find a significant increase in the number of patents applications and patent citations for firms affected by trade protection relative to other firms. Meanwhile, the results also indicate that this effect is stronger in non-state-owned enterprises (non-SOEs), as trade protection can relax the financial constraints of non-SOEs, while state-owned enterprises (SOEs) have stronger market power, national support and lower financial constraint. Moreover, the results also demonstrate that the provision of financing needs appears to be underlying economic channel through which trade protection encourages innovation.

I focus on the sample of China, and the reasons are as follows. First, it is widely believed that China's World Trade Organization (WTO) entry, with its promised market opportunities and guarantees, spurred the exceptional growth in China's export and import (Feng *et al.*, 2016). The import amount of China is increasing year by year, and the amount of China's import is 2.0784 trillion in the year of 2019, the second largest importer in the world only after the United States, which is 2.5674 trillion [1]. Second, the Chinese economy has become increasingly innovative (Wei *et al.*, 2017), and in the year of 2020, the number of patent applications worldwide reached 275,900, of which 68,720 were filed by China, surpassing the number 59,230 filed by the US [2]. Third, China has the second largest economy only after the US in the world, and some predict that China will be the world's largest economy within a decade (Liu *et al.*, 2019). As a result, it is essential to provide additional evidence for the relationship between trade protection and firm innovation in China.

This study contributes to the literature in the following ways. First, I shed light on the impact of international trade on firms' innovation, which has received a great deal of attention from researchers and practitioners (Golovko *et al.*, 2022; Hu and Yin, 2022; Liu *et al.*, 2022). In a series of studies, some studies find anti-dumping (AD) protection has positive and significant effects on domestic productivity (e.g. Crowley *et al.*, 2018), while Crowley (2006) shows that a safeguard will slow down technology adoption by foreign exporting firms, as safeguard tariffs can delay the foreign firm's adoption of new technology. Complementing these studies, this paper employs firm-level data of Chinese manufacturing firms and investigates the effect of trade protection on firm innovation, which suggests a positive relationship.

Second, this study also contributes to the emerging literature on the effect of trade policy uncertainty on financial constraint. Based on financial constraint theory, when faced with increasing uncertainty, banks will decrease the expectation and confidence of future income, adopting more stringent credit policies to avoid risk, and are more likely to reduce corporate credit rating (Demonier *et al.*, 2015). Therefore, enterprises with higher financing costs and tighter financing reviews could give up high-risk and high-return projects on account of insufficient financing, thus reducing the level of innovation (Wang *et al.*, 2021). I contribute to this nascent literature by examining the effects of trade protection on financial constraint, and this study indicates the mitigation of financial constraint after trade protection, as the spread of foreign firms exiting the Chinese market is faster than the spread of domestic firms entering the market.

Third, I add to the stream of literature on the drivers of innovation. One stream of literature focuses on trade policy uncertainty, and most of them investigate whether the decrease of trade policy uncertainty can encourage innovation. Aghion *et al.* (2022) show that a positive export shock spurs innovation for productive firms. Liu and Ma (2020) utilize China's accession to the WTO in 2001 as a quasi-natural experiment, and find that reduction in trade policy uncertainty significantly encourages firms' patent application. Coelli *et al.* (2022) provide evidence that trade liberalization encourages firms' patent filings. This paper differs from these prior studies, in that, I focus on trade protection and provide evidence that there is a bright side to trade protection: it promotes innovation.

The remainder of the paper is structured as follows. Section 2 reviews the literature. Section 3 gives hypothesis. Section 4 introduces methodology. Section 5 introduces data, variables and summary statistics. Section 6 examines the empirical relationship between trade protection and firm innovation and gives discussions. Section 7 concludes.

2. Literature review

There is a growing body of literature that recognizes the importance of trade protection, and numerous studies have examined its impact on firm performance. For example, Konings and Vandenbussche (2005) find that AD protection has positive and significant effects on domestic markups. Crowley (2006) shows that a broadly applied tariff like a safeguard can accelerate technology adoption by a domestic import-competing firm. Konings and Vandenbussche (2008) find that the productivity of the average firm receiving protection moderately improves. Rovegno (2013) finds evidence of a positive effect of antidumping and countervailing duties on domestic producers' price-cost margins for the period prior to the Uruguay Round.

However, some studies not only find the positive importance of trade protection but also demonstrate its negative effect. Glazer and Ranjan (2007) find that trade policies which aid a domestic industry also increase the domestic price of the traded good. Consumers who heavily consume the protected good may find that this price rise reduces the marginal utility of income. Kosteas (2008) finds that trade barriers may indirectly lower productivity by inhibiting the importation of foreign technologies through capital goods in the Mexican manufacturing sector. Jongwanich and Kohpaiboon (2017) find that trade protection allows firms to benefit in several ways, enhancing their productivity, while also discouraging their efforts to improve productivity due to the increased level of effective protection. Tian and Yu (2014) find empirical evidence that trade protection does not help much to increase a sector's relative size.

At the same time, some literature also gives examples of other countries which also indicate the significant effect of trade protection. It has been argued that reforms in India are credited with higher growth, and liberalization played a crucial role in stimulating growth during that decade (Panagariya, 2004). Using the data of Japanese foreign direct investment, Barrell and Pain (1999) find that investment was significantly influenced by trade protection measures, and by the level of antidumping actions initiated in the last decade. Using data in South Africa, Jonsson and Subramanian (2001) show that trade liberalization had a positive impact on total factor productivity (TFP) growth during the 1990s. Despite notable reform efforts, Athukorala (2006) finds that the structure of protection in Vietnam is still out of line with that of the major trading nations in the region, in terms of the level and the inter-industry dispersion of nominal and effective protection rates. Fernandes (2007) finds a strong positive impact of tariff liberalization on plant productivity in Colombian manufacturing industries, which is not driven by the endogeneity of protection. Using the Thai manufacturing sector as a case study, Jongwanich and Kohpaiboon (2017) find that trade protection will discourage firms' efforts to improve productivity.

Among the firm performance, innovation is a key driver of a nation's competitiveness and long-term economic growth (Solow, 1957; Porter, 1992), and prior studies have identified the effect of trade on firm innovation. Drawing on firm-level data, recent studies show that international trade can promote innovation by either intensifying competition or enlarging access to foreign markets (Liu and Ma, 2020). Coelli *et al.* (2022) provide evidence that trade liberalization encourages firms' patent filings, while Liu and Qiu (2016) find that input tariff reduction may discourage indigenous innovation by Chinese enterprises. However, prior literature has only investigated whether a positive export shock can spur innovation, nevertheless, whether trade protection can affect firm innovation remains relatively unexplored, and studying which has profound theoretical and practical significance.

3. Hypothesis

After the Chinese government adopts a trade protection policy for a certain type of product, the tariff for foreign companies exporting to China will increase, as a result, the cost of foreign products entering the Chinese market will also increase. Therefore, foreign firms will choose to reduce their export quantity to China or even withdraw from the Chinese market due to the increase in tariffs. As the demand for the domestic product remains unchanged, the supply of the product has decreased. According to the supply–demand theory, the price level of the domestic product will face an increase.

Higher prices for domestic products will lead to an increase in the firm's profit with constant costs, which in turn will ease the firm's financing constraints. Based on financial constraint theory, when faced with increasing uncertainty, banks will decrease the expectation and confidence of future income, adopting more stringent credit policies to avoid risk, and are more likely to reduce corporate credit rating (Bradley *et al.*, 2016). Therefore, enterprises with higher financing costs and tighter financing reviews could give up high-risk and high-return projects on account of insufficient financing, thus reducing the level of innovation (Wang *et al.*, 2021). The firm's concern for long-term benefits further inclines the firm to use its available profits for its technological innovations and promote its long-term growth. Based on this theory, I state the associated rebuttable hypothesis H1 as follows:

H1. An increase in trade protection induces innovation among Chinese listed firms.

Conversely, after domestic trade protection is adopted for a certain type of product, foreign firms' exports to China will decline, leading to a continued decline in the supply of goods in the domestic market, which in turn leads to weaker competition in the domestic product market. Drawing on firm-level data, recent studies suggest that international trade can promote innovation by intensifying competition or expanding access to foreign markets (Liu and Ma, 2020). Coelli *et al.* (2022) provide evidence that trade liberalization encourages firms to apply for patents, and Impullitti and Licandro (2018) find that trade liberalization promotes innovation by reducing markups to enhance competition, generate tighter firm selection and increase the level of aggregate productivity, which increases firms' incentives to innovate and thus leads to higher aggregate productivity growth rates. Thus, in the presence of lower competition in the domestic product market, firms' willingness to innovate decreases.

Moreover, in the presence of lower competition in the product market and increased firm profits, firms subsequently reduce their level of risk-taking and are reluctant to innovate. Based on these analyses, I propose the second hypothesis H2 as follows:

H2. Increased trade protection hinders innovation among Chinese listed firms.

4. Methodology

4.1 Univariate analysis

To investigate the relation between trade protection and innovation, I start with a univariate analysis by examining the innovation output after trade protection for all samples, and I implement a standard panel regression through the following regression:

$$Innovation_{i,t} = \beta_0 + \beta_1 Protection_{i,t-1} + \gamma Firm\ Characteristics_{i,t-1} + \delta Industry\ Characteristics_{i,t-1} + \theta Firm_i + \vartheta Year_{t-1} + \varepsilon_{i,t-1}, \quad (1)$$

where i indexes firm and t indexes time. $Innovation_{i,t}$ represents innovation output measures (patent or citation) for firm i in year t. The key independent variable $Protection_{i,t-1}$ equals to the natural logarithm of one plus the number of trade protection cases, which the firm i in the industry receives during the year $t-1$. β_1 captures the innovation effect due to trade protection cases. Firm and industry characteristics are the set of control variables, which will be described in Section 5.3. I include firm fixed effects to control the impact of unobservable time-invariant firm characteristics. Year fixed effects are included to account for the aggregate time variation in innovation output. The standard errors of the estimated coefficients allow for clustering of observations by firm.

4.2 2SLS regression

To further address the endogeneity, I also employ two-stage least squares (2SLS) regressions, and Producer Price Index (*PPI*) as the instrumental variable. In the first stage, I regress trade protection on the instrumental variable (*PPI*) and other control variables, and I can get the estimated trade protection. In the second stage, I regress the innovation on the estimated trade protection obtained from the first stage and other control variables. The 2SLS regressions I employ are as follows:

$$Protection_{i,t-1} = \beta_0 + \beta_1 PPI_{i,t-1} + \gamma Firm\ Characteristics_{i,t-1} + \delta Industry\ Characteristics_{i,t-1} + \theta Firm_i + \vartheta Year_{t-1} + \varepsilon_{i,t-1}, \quad (2)$$

$$Innovation_{i,t} = \beta_0 + \beta_1 Trade\ \widehat{Protection}_{i,t-1} + \gamma Firm\ Characteristics_{i,t-1} + \delta Industry\ Characteristics_{i,t-1} + \theta Firm_i + \vartheta Year_{t-1} + \varepsilon_{i,t-1}, \quad (3)$$

where i indexes firm, t indexes time, *PPI* is Producer Price Index, which is used as instrumental variable, and other variables are defined in Equation (1).

5. Sample formation and variable construction

5.1 Data and sample

The data sample consists of Chinese A-share manufacturing companies during the period of 2003–2019, and I focus solely on manufacturing industries because they are the most innovative and hence the most relevant industries (Moshirian *et al.*, 2021) [3]. In addition, special treatment stocks are omitted due to poor financial performance. After excluding observations that do not have all available data for the baseline analysis, the final sample consists of 9,416 firm-year observations.

I gather the sample from several sources as follows. I collect patent data from the Chinese Research Data Services Platform (CNRDS) database for 2003–2019, which includes detailed information regarding the classification of the patent (substantive patent or strategic patent), the date of application and grant, and the number of citations. The data of trade protection is sourced from the website of China Trade Remedies Information, while financial data of manufacturing firms are obtained from the China Securities Market and Accounting Research (CSMAR) database.

5.2 Measure of firm innovation

I mainly use three measures for innovation output, the definitions of which are reported in Table A1. The first measure is the natural logarithm of one plus the number of patent applications filed by the firm in a year. Patent counts are a good indicator of the level of innovation output, as patenting is an important means by which firms can protect their technological inventions (Chang *et al.*, 2019). The second measure of innovation output is the natural logarithm of one plus the number of patents filed by the firm each year that are eventually granted, which is used as robustness check. The number of patents obtained measures a firm's patenting productivity, and has also been extensively examined in earlier innovation studies (e.g. Fang *et al.*, 2014; Chang *et al.*, 2015). The third measure is the natural logarithm of one plus the number of forward citations of a patent, which captures the quality and significance of a firm's innovation activity (Li *et al.*, 2020; Liu and Ma, 2020). The use of citation numbers to proxy for innovation can largely mitigate the measurement issues arising from the patent application system, as identified in the literature, including trivial patents being awarded and anticompetitive behavior (Jaffe and Lerner, 2004).

5.3 Measure of trade protection and control variables

I collect the data of trade protection from the website of China Trade Remedies Information, a public information service project sponsored by the Ministry of Commerce. The database includes detailed information regarding the classification (AD, countervailing or safeguards), industry and the data of the trade protection. I use the natural logarithm of one plus the number of trade protection cases received by the industry to which the firm belongs in a particular year to proxy for trade protection, which captures the extent of trade protection received by the firm.

Following the innovation literature, I control a vector of firm and industry characteristics that may affect a firm's patenting activities, which are all sourced from CSMAR. I provide detailed variable definitions in Table A1. In the baseline regressions, the control variables include leverage, fixed assets, profitability, cash, firm size, capital expenditures scaled by total assets, growth opportunities, percentage of ownership, and firm age. I also include industry concentration (the Herfindahl index (HHI) and the squared Herfindahl index (HHI_Square) to mitigate the nonlinear effects of product market competition on innovation output (Aghion *et al.*, 2005).

5.4 Descriptive statistics

Table 1 provides summary statistics of the final sample that consists of 9,416 firm years. On average, firms in the sample have 3.01 patents filed per year, and 2.24 of which are granted. Meanwhile, patents have been cited 2.75 times on average over the sample period. The average of the trade protection for Chinese manufacturing companies is 1.54 per year. As for each trade protection, it lasts 6.63 years on average.

6. Main results

This section explores the empirical relation between trade protection and innovation. I first test this effect with the method of panel regression. Next, I investigate the long-term relationship between trade protection and innovation. I also examine how this effect varies between heterogeneity of firm ownership. At last, I address the endogeneity issue.

6.1 Baseline results

The baseline regression results of Equation (1) are presented in Table 2. As shown in Table 2, Column (1) reports the results for the total number of patents applied by firm i in

Table 1. Summary statistics

	N (1)	Max (2)	Mean (3)	Min (4)	SD (5)
Pat	9,416	3.01	1.85	0.00	10.63
Sub	9,416	2.25	1.67	0.00	9.86
Str	9,416	2.26	1.88	0.00	10.01
GrantPat	9,415	2.24	1.58	0.00	9.21
GrantSub	9,415	1.18	1.19	0.00	7.76
GrantStr	9,415	1.87	1.62	0.00	8.95
Citation	5,417	2.75	1.40	0.00	9.76
Protection	9,416	1.54	1.40	0.00	4.26

Note(s): This table presents the summary statistics of the full sample, which consists of 9,416 firm-year observations from 2003 to 2019. Definitions of all variables are detailed in Table A1. I obtain patent information from the CNRDS patent database, trade protection information from the website of China Trade Remedies Information, and financial information from CSMAR database

year t. I also assess how trade protection affects different types of a firm's innovation activities and output, i.e. substantive patents and strategic patents, which are presented in Columns (2) and (3), respectively. In Columns (1) and (2), the coefficients on the key variable of interest, $Protection_{i,t-1}$, are both positive and statistically significant at the 5% level, suggesting a positive effect of trade protection on the number of patents, particularly substantive patents. The economic magnitude is also sizeable. For example, the coefficient on $Protection_{i,t-1}$ is 0.0896 in Column (1) and is significant at the 5% level, indicating that $Protection_{i,t-1}$ leads to an increase in the number of patents by approximately 9.37% ($= e^{0.0896} - 1$). In Column (3), the coefficient on $Protection_{i,t-1}$ is positive, but insignificant, indicating that trade protection cannot spur the number of strategic patents.

Taken together, these results indicate a positive effect of trade protection measures on innovation outputs in terms of substantive patents and total patents.

6.2 The long-term effect of trade protection on firm innovation

Having found positive relationship between trade protection and firm innovation, I next construct the indicator of firm innovation output in the year t+1 to t+4 instead of t in the baseline model to account for the possibility that trade protection can take more than one year to have effects on innovation and further capture the long-term nature of the innovation process (Manso, 2011). The model specifications I employ are as follows:

$$\begin{aligned} Innovation_{i,t+n} = \beta_0 + \beta_1 Protection_{i,t-1} + \gamma Firm\ Characteristics_{i,t-1} \\ + \delta Industry\ Characteristics_{i,t-1} + \theta Firm_i + \vartheta Year_{t-1} + \varepsilon_{i,t-1}, \end{aligned} \quad (4)$$

where i indexes firm, t indexes time, n is the year after trade protection and other variables are defined in Equation (1). I include firm fixed effects to control the impact of unobservable time-invariant firm characteristics. Year fixed effects are included to account for the aggregate time variation in innovation output. The standard errors of the estimated coefficients allow for clustering of observations by firm. The results are presented in Table 3.

From the four coefficients of $Protection_{i,t-1}$ reported in Table 3, they are all positive and statistically significant at the 1% level. It means that trade protection has a long-term effect on firm innovation, as the firm has a greater incentive to innovate in the next few years when receiving trade protection.

	Pat_t (1)	Sub_t (2)	Str_t (3)
$Protection_{t-1}$	0.0896**	0.0874**	0.0303
	(2.13)	(2.36)	(0.76)
$Leverage_{t-1}$	0.1464	0.0525	0.2526
	(0.83)	(0.33)	(1.38)
Fix_{t-1}	0.4379*	0.3842*	0.5222**
	(1.87)	(1.89)	(2.21)
ROA_{t-1}	0.6820**	0.6908***	0.4391
	(2.33)	(2.85)	(1.44)
$Cash_{t-1}$	−0.1690	−0.2739**	−0.1241
	(−1.29)	(−2.31)	(−0.92)
$Size_{t-1}$	0.4446***	0.4609***	0.4310***
	(8.19)	(8.85)	(7.95)
$Tobin's\ Q_{t-1}$	−0.1023***	−0.0978***	−0.0991***
	(−3.32)	(−3.23)	(−3.19)
$Top1_{t-1}$	−0.0023	−0.0021	0.0015
	(−0.62)	(−0.63)	(0.44)
$Top10_{t-1}$	0.0052*	0.0033	0.0029
	(1.81)	(1.23)	(1.02)
Age_{t-1}	0.1962	−0.0303	0.2074
	(0.93)	(−0.15)	(0.98)
HHI_{t-1}	4.8630***	4.8514***	3.8586**
	(2.61)	(2.95)	(1.99)
HHI_Square_{t-1}	−10.3407*	−10.6669**	−9.7511
	(−1.73)	(−2.09)	(−1.58)
Intercept	−2.8643***	−3.0918***	−3.1013***
	(−5.22)	(−6.13)	(−5.46)
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
R-squared	0.364	0.363	0.312
Observations	9,416	9,416	9,416

Note(s): This table reports the results of baseline regressions that examine the impacts of trade protection on firm innovation during the period 2003–2019. In Column (1), the dependent variable is *Pat*, while the dependent variables of Columns (2) and (3) are *Sub* and *Str*, respectively. The independent variable is *Protection*. Variables are defined in Table A1. The dependent variables are measured in year t and independent variables are measured in year $t-1$. The regressions include firm and year fixed effects. T-statistics based on robust standard errors clustered at the firm level are in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively

Table 2.
Trade protection and firm innovation

6.3 Heterogeneity analysis of ownership

The baseline results imply a positive and causal relation between trade protection and corporate innovation with the full sample, I then divide the firms into different subsamples based on the ownership. Table 4 separately considers the heterogeneous responses of firms with different ownership. China embarked on a very large-scale privatization reform on SOEs in the late 1990s, which resulted in the privatization or closure of small and medium SOEs and stimulated the entry of many private firms (Berkowitz *et al.*, 2017). I consider two types of firms: SOEs and non-SOEs, including both domestic privately owned firms and foreign-invested enterprises.

Interestingly, trade protection has a significant effect on innovation by non-SOEs, while the effect is not significant for SOEs. The significant response from non-SOEs is understandable that non-SOEs have lower market power, national support and higher financial constraint, with most innovation activities involving long-term, risky and idiosyncratic investment in intangible assets (Holmstrom, 1989). When receiving trade protection, non-SOEs face to lower financial constraint, which can spur innovation.

	Pat_{t+n}			
	$n = 1$ (1)	$n = 2$ (2)	$n = 3$ (3)	$n = 4$ (4)
$Protection_{t-1}$	0.2087***	0.2376***	0.3370***	0.3907***
	(3.67)	(3.91)	(4.86)	(5.23)
$Leverage_{t-1}$	0.1955	−0.0140	0.0336	0.2123
	(0.99)	(−0.07)	(0.15)	(0.87)
Fix_{t-1}	0.5556**	0.9807***	0.8767***	0.8059**
	(2.13)	(3.43)	(3.01)	(2.50)
ROA_{t-1}	0.1202	−0.5037	−0.7072**	−0.7801***
	(0.43)	(−1.55)	(−2.56)	(−2.65)
$Cash_{t-1}$	−0.3052**	−0.0308	0.3920**	0.2873*
	(−2.13)	(−0.21)	(2.52)	(1.66)
$Size_{t-1}$	0.5089***	0.5266***	0.4550***	0.3119***
	(8.05)	(8.86)	(6.99)	(4.19)
$Tobin's\ Q_{t-1}$	−0.1275***	−0.1397***	−0.1200***	−0.0738***
	(−3.27)	(−6.90)	(−5.64)	(−3.56)
$Top1_{t-1}$	−0.0036	−0.0048	−0.0066	−0.0042
	(−0.88)	(−1.14)	(−1.60)	(−0.93)
$Top10_{t-1}$	0.0048	−0.0004	−0.0068**	−0.0121***
	(1.53)	(−0.12)	(−2.03)	(−3.07)
Age_{t-1}	0.2235	0.0092	−0.1210	0.1215
	(0.82)	(0.03)	(−0.27)	(0.21)
HHI_{t-1}	5.3227**	4.7463**	6.5320**	7.4136**
	(2.52)	(1.99)	(2.37)	(2.31)
HHI_Square_{t-1}	−11.9607*	−11.6855	−16.6806*	−17.0285*
	(−1.70)	(−1.52)	(−1.94)	(−1.69)
Intercept	−3.5183***	−2.9341***	−2.0711*	−1.7697
	(−5.10)	(−3.42)	(−1.90)	(−1.26)
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
R-squared	0.402	0.392	0.367	0.341
Observations	8,203	7,086	6,195	5,383

Note(s): This table reports the results of baseline regressions that examine the long-term impacts of trade protection on firm innovation during the period 2003–2019. The dependent variable is *Pat* in year $t + n$. The independent variable is *Protection*. Variables are defined in Table A1. The independent variables are measured in year $t-1$. The regressions include firm and year fixed effects. *T*-statistics based on robust standard errors clustered at the firm level are in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively

Table 3. Trade protection and firm innovation: long-term effect

6.4 Endogeneity

A reasonable concern of the baseline results is that omitted variables correlated with both trade protection and patenting performance may bias the results. In addition, there is a potential reverse causality concern that innovative-intensive firms may be protected by the government. I attempt to address these concerns in this subsection.

I first re-tabulate the coefficients corresponding to *Protection* after controlling one-period lagged dependent variables. The regressions I implement are as follows:

$$\begin{aligned} Innovation_{i,t} = {} & \beta_0 + \beta_1 Protection_{i,t-1} + \beta_2 Innovation_{i,t-1} + \gamma Firm\ Characteristics_{i,t-1} \\ & + \delta Industry\ Characteristics_{i,t-1} + \theta Firm_i + \vartheta Year_{t-1} + \varepsilon_{i,t-1}, \end{aligned} \tag{5}$$

where i indexes firm, t indexes time and other variables are defined in Equation (1). The results are reported in Table 5. I find that, consistent with the baseline findings, the increase in

Table 4.
Trade protection and firm innovation: SOEs versus non-SOEs

	Pat_t (1)	Sub_t (2)	Str_t (3)
Panel A: SOEs			
$Protection_{t-1}$	0.0348	0.0615	−0.0653
	(0.66)	(1.32)	(−1.28)
$Leverage_{t-1}$	0.2220	0.0533	0.2272
	(0.70)	(0.19)	(0.68)
Fix_{t-1}	0.4146	0.3281	0.5711
	(1.16)	(1.07)	(1.58)
ROA_{t-1}	0.7589	1.1786**	0.3719
	(1.46)	(2.48)	(0.68)
$Cash_{t-1}$	−0.3921	−0.3931*	−0.3777
	(−1.58)	(−1.73)	(−1.54)
$Size_{t-1}$	0.4993***	0.4797***	0.4770***
	(5.75)	(5.37)	(5.19)
$Tobin's\ Q_{t-1}$	−0.2201***	−0.2014***	−0.2068***
	(−6.37)	(−6.35)	(−5.59)
$Top1_{t-1}$	−0.0055	−0.0034	−0.0038
	(−1.07)	(−0.69)	(−0.76)
$Top10_{t-1}$	0.0066	0.0019	0.0076*
	(1.58)	(0.47)	(1.73)
Age_{t-1}	0.9049**	0.5127	0.6132
	(2.19)	(1.27)	(1.43)
HHI_{t-1}	5.5519**	6.8561***	2.4749
	(2.11)	(2.83)	(0.84)
HHI_Square_{t-1}	−12.8518*	−16.4622**	−8.7689
	(−1.83)	(−2.53)	(−1.03)
Intercept	−4.9028***	−4.3539***	−4.4563***
	(−4.67)	(−4.57)	(−3.99)
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
R-squared	0.444	0.450	0.356
Observations	3,606	3,606	3,606
	(4)	(5)	(6)
Panel B: Non-SOEs			
$Protection_{t-1}$	0.1561**	0.1040*	0.1812***
	(2.53)	(1.75)	(3.03)
$Leverage_{t-1}$	−0.1145	−0.1013	0.1213
	(−0.57)	(−0.53)	(0.57)
Fix_{t-1}	0.3845	0.3931	0.4090
	(1.35)	(1.56)	(1.35)
ROA_{t-1}	0.5373	0.4077	0.4771
	(1.53)	(1.50)	(1.32)
$Cash_{t-1}$	0.0277	−0.1349	0.0653
	(0.20)	(−1.05)	(0.43)
$Size_{t-1}$	0.5100***	0.5265***	0.4881***
	(7.53)	(8.46)	(7.21)
$Tobin's\ Q_{t-1}$	−0.0703***	−0.0726***	−0.0704***
	(−2.83)	(−2.78)	(−2.72)
$Top1_{t-1}$	0.0082	0.0046	0.0126**
	(1.58)	(0.98)	(2.52)
$Top10_{t-1}$	−0.0024	−0.0007	−0.0048
	(−0.65)	(−0.20)	(−1.35)

(*continued*)

	(4)	(5)	(6)
Age_{t-1}	−0.1553	−0.3355	−0.0457
	(−0.62)	(−1.38)	(−0.18)
HHI_{t-1}	3.6438	2.9378	4.7202*
	(1.39)	(1.32)	(1.83)
HHI_Square_{t-1}	−10.3204	−8.4289	−12.3706
	(−1.16)	(−1.17)	(−1.45)
Intercept	−1.8621***	−2.6004***	−2.4339***
	(−2.74)	(−4.13)	(−3.52)
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
R-squared	0.297	0.284	0.288
Observations	5,810	5,810	5,810

Note(s): This table reports the results of baseline regressions that examine the impacts of trade protection on firm innovation based on subsamples, which are sorted by ownerships. In Panel A, the results are based on the sample of state-owned enterprises (SOEs), while the results of other enterprises (non-SOEs) are reported in Panel B. In Column (1), the dependent variable is *Pat*, while the dependent variables of Columns (2) and (3) are *Sub* and *Str*, respectively. The independent variable is *Protection*. Variables are defined in Table A1. The dependent variables are measured in year t and independent variables are measured in year t−1. The regressions include firm and year fixed effects. T-statistics based on robust standard errors clustered at the firm level are in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively

Table 4.

trade protection is also associated with more patent applications after controlling one-period lagged patent application.

To further address the endogeneity, I also employ two-stage least squares (2SLS) regressions, and Producer Price Index (*PPI*) as the instrumental variable. The results obtained from the instrumental variable approach in the framework of 2SLS regression are reported in Table 6.

In the first stage, I regress $Protection_{i,t-1}$ on the instrumental variables and control variables, as presented in Column (1). The coefficient on the instrumental variable is both significant and negative, demonstrating that this instrumental variable is efficient. In the second stage, I regress the innovation on the estimated *Protection* obtained from the first stage and the other control variables, as presented in Columns (2) to (4) of Table 6. The results of the second-stage regressions are like these of baseline regressions, as the coefficients on *Protection* of Columns (2) and (3) are statistically significant and positive, suggesting that the result of Table 2 is not driven by endogenous selection.

6.5 Robustness checks

In this section, several robustness checks are performed to confirm the results presented in Section 6.1. First, I winsorize continuous variables at the 0.5, 1 and 2% levels at both tails of their distributions to recompute the coefficients. Second, I retest the relationship between trade protection and firm innovation based on the sample with nonzero observations. Lastly, I conduct additional robustness tests using alternative proxies for firm innovation.

6.5.1 Sample after winsorization. Financial data are notoriously subject to outliers (extreme data points). In many statistical analyses, such data points may exert an undue influence on the results, making the results unreliable. While there are several statistical methods designed to assess the effect of outliers or ameliorate their effect on results, such as winsorization (Chang *et al.*, 2019; Li *et al.*, 2020). The results based on the sample after winsorization are reported in Table 7, and variables are winsorized at the 0.5, 1 and 2% levels. As reported in Table 7, I show a strong and significant impact of trade protection on firm innovation after winsorization.

Table 5.
Trade protection and firm innovation: controlling one-period lagged dependent variables

	Pat_t (1)	Sub_t (2)	Str_t (3)
$Protection_{t-1}$	0.0623*	0.0559*	0.0266
	(1.85)	(1.91)	(0.76)
Pat_{t-1}	0.3251***		
	(15.69)		
Sub_{t-1}		0.3127***	
		(16.92)	
Str_{t-1}			0.2622***
			(13.41)
$Leverage_{t-1}$	0.1697	0.0556	0.3204*
	(1.10)	(0.40)	(1.84)
Fix_{t-1}	0.4464**	0.3738**	0.5991***
	(2.38)	(2.18)	(3.02)
ROA_{t-1}	0.0985	0.2225	0.0378
	(0.28)	(0.72)	(0.10)
$Cash_{t-1}$	−0.1446	−0.2604**	−0.1202
	(−1.13)	(−2.21)	(−0.91)
$Size_{t-1}$	0.3762***	0.3846***	0.3809***
	(8.16)	(8.27)	(7.54)
$Tobin's\ Q_{t-1}$	−0.0736***	−0.0746***	−0.0783***
	(−3.11)	(−2.92)	(−3.04)
$Top1_{t-1}$	−0.0023	−0.0011	−0.0012
	(−0.79)	(−0.40)	(−0.39)
$Top10_{t-1}$	0.0041*	0.0031	0.0028
	(1.73)	(1.40)	(1.12)
Age_{t-1}	0.0803	−0.0325	−0.0099
	(0.48)	(−0.20)	(−0.05)
HHI_{t-1}	2.9105**	2.6848**	3.1208**
	(2.08)	(2.16)	(1.98)
HHI_Square_{t-1}	−6.3073	−5.9572	−8.0671
	(−1.47)	(−1.63)	(−1.63)
Intercept	−2.4898***	−2.7397***	−2.5039***
	(−5.57)	(−6.77)	(−4.92)
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
R-squared	0.460	0.460	0.368
Observations	8,206	8,206	8,206

Note(s): This table reports the results of baseline regressions that examine the impacts of trade protection on innovation output after controlling for one-period lagged dependent variables. In Column (1), the dependent variable is *Pat*, while the dependent variables of Columns (2) and (3) are *Sub* and *Str*, respectively. The independent variable is *Protection*. Variables are defined in Table A1. The dependent variables are measured in year t and independent variables are measured in year $t-1$. The regressions include firm and year fixed effects. T-statistics based on robust standard errors clustered at the firm level are in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively

6.5.2 Sample with nonzero observations. In the baseline regressions, I follow the literature to set the patent counts to zero for firm-year observations that do not have patent information available. To rule out the possibility that the results are driven by firm-year observations with zero patents, I restrict my analysis to a subsample of nonzero observations (i.e. firm years with at least one patent) and rerun the regression for which the dependent variable is the number of patent applications. In the tabulated analysis of Table 8, I find a significantly positive coefficient estimate on *Protection*.

6.5.3 Alternative proxies for innovation. In previous sections, I established the average effect of trade protection on innovation output, which is measured as the number of patent

Table 6. Two-stage least squares (2SLS) regressions

	Panel A: First stage	Panel B: Second stage		
	$Protection_{t-1}$	Pat_t	Sub_t	Str_t
	(1)	(2)	(3)	(4)
$Protection_{t-1}$		0.0015*	0.0013*	0.0013
		(1.92)	(1.74)	(1.61)
PPI_{t-1}	−0.0067***			
	(−4.39)			
$Leverage_{t-1}$	0.1845***	0.1924	0.0766	0.2889
	(2.68)	(1.10)	(0.49)	(1.59)
Fix_{t-1}	0.2844***	0.5321**	0.4515**	0.6027**
	(2.91)	(2.26)	(2.19)	(2.55)
ROA_{t-1}	0.0154	0.8921***	0.7952***	0.6448**
	(0.16)	(3.18)	(3.20)	(2.21)
$Cash_{t-1}$	0.0842*	−0.1928	−0.2830**	−0.1520
	(1.82)	(−1.46)	(−2.36)	(−1.12)
$Size_{t-1}$	−0.0438**	0.4292***	0.4484***	0.4186***
	(−2.06)	(7.98)	(8.61)	(7.78)
$Tobin's\ Q_{t-1}$	−0.0069*	−0.1022***	−0.0973***	−0.0987***
	(−1.91)	(−3.34)	(−3.25)	(−3.20)
$Top1_{t-1}$	−0.0014	−0.0025	−0.0023	0.0013
	(−1.04)	(−0.68)	(−0.68)	(0.38)
$Top10_{t-1}$	−0.0004	0.0045	0.0026	0.0023
	(−0.37)	(1.54)	(0.98)	(0.81)
Age_{t-1}	0.0319	0.2494	0.0170	0.2519
	(0.35)	(1.19)	(0.08)	(1.19)
HHI_{t-1}	−0.8540	4.4690**	4.6124***	3.4876*
	(−1.46)	(2.39)	(2.79)	(1.79)
HHI_Square_{t-1}	3.3597***	−9.3747	−10.0168**	−8.9263
	(2.63)	(−1.57)	(−1.97)	(−1.45)
Intercept	0.8944***	−2.1751***	−2.4712***	−2.5257***
	(3.48)	(−3.43)	(−4.12)	(−3.88)
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
R-squared	0.524	0.365	0.363	0.313
Observations	9,320	9,320	9,320	9,320

Note(s): This table presents results from 2SLS regressions between 2003 and 2019. In the first stage, I regress trade protection on the instrumental variable (*PPI*) and other control variables. In the second stage, I regress the innovation on the estimated trade protection obtained from the first stage and other control variables. In Column (1), the dependent variable is *Protection*. In Column (2), the dependent variable is *Pat*. The dependent variables of Columns (3) and (4) are *Sub* and *Str*, respectively. The instrumental variable *PPI* is Producer Price Index. Variables are defined in Table A1. I report the results of both first-stage and second-stage regressions. The regressions include firm and year fixed effects. *T*-statistics based on robust standard errors clustered at the firm level are in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively

applications. I next examine the effect of trade protection on innovation output with alternative proxies for innovation. First, instead of the number of patent applications, I re-estimate the results using the number of patent grants to proxy for innovation output, which are reported in Columns (1) to (3) of Table 9. The use of application and grant numbers to proxy for innovation represents the quantity for innovation, and I then employ citation numbers to proxy the quality for innovation, which can largely mitigate the measurement issues arising from the patent application system. I report the results in Column (4) of Table 9, showing similar results. From the results shown in Table 9, I find that firms exhibit a higher level of innovation output, both quantity and quality, after receiving trade protection.

Table 7. Robustness tests with sample after winsorization

	Pat_t 0.5% level (1)	1% level (2)	2% level (3)
$Protection_{t-1}$	0.0840**	0.0805*	0.0753*
	(2.03)	(1.94)	(1.82)
$Leverage_{t-1}$	0.1080	0.1015	0.0964
	(0.60)	(0.55)	(0.51)
Fix_{t-1}	0.4360*	0.4378*	0.4282*
	(1.87)	(1.87)	(1.79)
ROA_{t-1}	1.0477***	1.1539***	1.2636***
	(3.04)	(3.09)	(3.00)
$Cash_{t-1}$	−0.1356	−0.1496	−0.1773
	(−1.02)	(−1.10)	(−1.25)
$Size_{t-1}$	0.4944***	0.4920***	0.4854***
	(9.82)	(9.62)	(9.27)
$Tobin's\ Q_{t-1}$	−0.1849***	−0.1938***	−0.2103***
	(−10.16)	(−9.91)	(−9.52)
$Top1_{t-1}$	−0.0018	−0.0018	−0.0019
	(−0.51)	(−0.51)	(−0.52)
$Top10_{t-1}$	0.0039	0.0037	0.0035
	(1.36)	(1.30)	(1.23)
Age_{t-1}	0.2558	0.3280	0.4711*
	(1.16)	(1.41)	(1.86)
HHI_{t-1}	5.1709***	4.4024*	4.0940
	(2.59)	(1.70)	(1.55)
HHI_Square_{t-1}	−11.6802*	−7.4514	−5.3003
	(−1.66)	(−0.65)	(−0.44)
Intercept	−3.1758***	−3.2631***	−3.4609***
	(−5.70)	(−5.70)	(−5.70)
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
R-squared	0.366	0.363	0.360
Observations	9,416	9,416	9,416

Note(s): This table reports the results of panel regressions that examine the impacts of trade protection on innovation output after winsorization. In Column (1), all variables are winsorized at the 0.5% level at both tails of their distributions, while at the 1 and 2% levels in Columns (2) and (3), respectively. The dependent variable is *Pat*. The independent variable is *Protection*. Variables are defined in Table A1. The dependent variables are measured in year t and independent variables are measured in year $t-1$. The regressions include firm and year fixed effects. T-statistics based on robust standard errors clustered at the firm level are in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively

6.6 Economic channel

While I have shown a robust positive relation between trade protection and corporate innovation, its causal interpretation remains hypothetical. In this section, I explore the plausible underlying economic channel through which trade protection encourages innovation output, which is the mitigation of financial constraint.

After a trade protection policy is adopted by Chinese government, foreign product will exit Chinese market in response to increasing tariff, and the price of domestic product faces to increase. As a result, the financial constraint of domestic firms will relax. The enterprises' attention to long-term interests further inclines the enterprises toward technological innovation. It can be said that the financial constraint faced by enterprises acts as the transmission channel through which trade protection promotes corporate technological innovation.

	Pat_t (1)	Sub_t (2)	Str_t (3)
$Protection_{t-1}$	0.1495***	0.1613***	0.1122**
	(3.73)	(3.92)	(2.51)
$Leverage_{t-1}$	0.0267	0.0240	0.1110
	(0.18)	(0.16)	(0.65)
Fix_{t-1}	0.4865**	0.4717***	0.2511
	(2.56)	(2.64)	(1.14)
ROA_{t-1}	0.8261***	0.6450***	0.6375**
	(3.44)	(2.73)	(2.23)
$Cash_{t-1}$	−0.1505	−0.2628**	0.0345
	(−1.49)	(−2.47)	(0.29)
$Size_{t-1}$	0.4370***	0.4334***	0.4149***
	(9.69)	(8.43)	(8.18)
$Tobin's\ Q_{t-1}$	−0.1278***	−0.1121***	−0.1049***
	(−8.17)	(−6.67)	(−5.68)
$Top1_{t-1}$	−0.0000	0.0003	0.0005
	(−0.01)	(0.10)	(0.17)
$Top10_{t-1}$	0.0024	0.0010	0.0010
	(1.05)	(0.44)	(0.39)
Age_{t-1}	0.0978	−0.3014	0.1243
	(0.55)	(−1.50)	(0.66)
HHI_{t-1}	3.2408**	2.6911*	1.8210
	(2.10)	(1.85)	(1.07)
HHI_Square_{t-1}	−8.1056	−6.1016	−5.9588
	(−1.51)	(−1.29)	(−1.03)
Intercept	−1.5751***	−1.4106***	−1.3296**
	(−3.29)	(−2.92)	(−2.44)
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
R-squared	0.392	0.361	0.331
Observations	7,872	7,179	6,541

Note(s): This table reports the results of panel regressions that examine the impacts of trade protection on innovation output with the sample of nonzero observations during the period 2003–2019. In Column (1), the dependent variable is *Pat*. The dependent variables of Columns (2) and (3) are *Sub* and *Str*, respectively. The independent variable is *Protection*. Variables are defined in Table A1. The dependent variables are measured in year t and independent variables are measured in year $t-1$. The regressions include firm and year fixed effects. T-statistics based on robust standard errors clustered at the firm level are in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively

Table 8. Robustness tests with sample of nonzero observations

Following Hadlock and Pierce (2010), I apply SA Index as an indicator of the financial constraint level to proxy the variation in the total financial resources, which is arguably the most exogenous measure (Hao and Li, 2016; Wang *et al.*, 2021). The *SA Index* is defined as follows:

$$SA\ Index = -0.737 * \mathrm{Size} + 0.043 * Size^2 - 0.040 * Age, \quad (6)$$

where *SA Index* is the indicator of the financial constraint, and Size and *Age* represent the market value and the number of years since the Initial Public Offering (IPO). The model that examines the mediating effect of financial constraint consists of the following two groups of equations:

$$SA\_Index_{i,t} = \beta_0 + \beta_1 Protection_{i,t-1} + \gamma Firm\ Characteristics_{i,t-1} + \delta Industry\ Characteristic_{i,t-1} + \theta Firm_i + \vartheta Year_{t-1} + \varepsilon_{i,t-1}, \quad (7)$$

	$GrantPat_t$ (1)	$GrantSub_t$ (2)	$GrantStr_t$ (3)	$Citation_t$ (4)
$Protection_{t-1}$	0.0728**	0.0691**	0.0698**	0.1648***
	(2.14)	(2.54)	(2.10)	(3.42)
$Leverage_{t-1}$	0.0762	−0.0274	0.1674	−0.0073
	(0.50)	(−0.22)	(1.06)	(−0.04)
Fix_{t-1}	0.4867**	0.3255**	0.5330***	0.5163**
	(2.47)	(2.02)	(2.64)	(2.28)
ROA_{t-1}	−0.0493	−0.4762***	0.1730	0.9953***
	(−0.21)	(−2.89)	(0.72)	(2.82)
$Cash_{t-1}$	−0.1384	−0.0134	−0.1664	−0.3932***
	(−1.24)	(−0.15)	(−1.47)	(−2.79)
$Size_{t-1}$	0.4587***	0.3848***	0.4215***	0.3658***
	(9.51)	(9.19)	(8.56)	(5.65)
$Tobin's\ Q_{t-1}$	−0.0965***	−0.0779***	−0.0891***	−0.0540**
	(−3.16)	(−3.08)	(−3.07)	(−2.50)
$Top1_{t-1}$	−0.0000	0.0014	0.0006	−0.0001
	(−0.00)	(0.53)	(0.18)	(−0.02)
$Top10_{t-1}$	0.0039	0.0021	0.0025	0.0039
	(1.56)	(0.98)	(1.00)	(1.29)
Age_{t-1}	0.3369*	0.0114	0.2309	−0.3071
	(1.82)	(0.07)	(1.15)	(−1.27)
HHI_{t-1}	3.9708**	2.9353**	3.6716**	−0.1012
	(2.48)	(2.18)	(2.16)	(−0.06)
HHI_Square_{t-1}	−8.9742*	−7.5256**	−9.7832*	1.6060
	(−1.76)	(−2.20)	(−1.80)	(0.35)
Intercept	−3.7106***	−2.9557***	−3.3222***	−0.3673
	(−7.31)	(−6.79)	(−6.15)	(−0.64)
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
R-squared	0.406	0.353	0.328	0.344
Observations	9,415	9,415	9,415	5,417

Note(s): This table reports the results of panel regressions that examine the impact of trade protection on alternative proxies for innovation output, which are the amount of patent granted and the number of patent citation, during the period of 2003–2019. In Column (1), the dependent variable is *GrantPat*. The dependent variables of Columns (2) and (3) are *GrantSub* and *GrantStr*, respectively. In Column (4), the dependent variable is *Citation*. The independent variable is *Protection*. Variables are defined in Table A1. The dependent variables are measured in year t and independent variables are measured in year $t-1$. The regressions include firm and year fixed effects. T-statistics based on robust standard errors clustered at the firm level are in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively

Table 9. Robustness tests with alternative proxies for innovation

$$Innovation_{i,t} = \beta_0 + \beta_1 Protection_{i,t-1} + \beta_2 SA\_Index_{i,t} + \gamma Firm\ Characteristics_{i,t-1} + \delta Industry\ Characteristics_{i,t-1} + \theta Firm_i + \vartheta Year_{t-1} + \varepsilon_{i,t-1}, \quad (8)$$

where i indexes firm, t indexes time, *SA_Index* is SA Index representing financial constraint, and other variables are defined in Equation (1).

Table 10 reports the empirical results for the economic channel of financial constraint. As observable, Column (1) is the estimation result of Equation (7), showing that the estimated coefficient of $Protection_{i,t-1}$ is negative, and significant at the 5% level, which indicates that trade protection tends to relax financial constraint. Then, Column (2) reports the dependent variable corporate technological innovation's regression results, on the basic variable $Protection_{i,t-1}$ and the intermediary variable financial constraint. The results of this reveal that the estimation coefficient of financial constraint is negative, and has passed the

	$SA\ Index_t$ (2)	$Patent_t$ (3)
$Protection_{t-1}$	−0.0089**	0.1389**
	(−2.28)	(2.38)
$SA\ Index_t$		−1.0065**
		(−2.37)
$Leverage_{t-1}$	0.0107	−0.0208
	(0.82)	(−0.11)
Fix_{t-1}	−0.0287*	0.3275
	(−1.81)	(1.27)
ROA_{t-1}	0.0389**	0.5849*
	(2.37)	(1.76)
$Cash_{t-1}$	−0.0235***	−0.1938
	(−3.13)	(−1.28)
$Size_{t-1}$	−0.0312***	0.3940***
	(−5.65)	(6.66)
$Tobin's\ Q_{t-1}$	0.0059***	−0.0945***
	(3.34)	(−3.26)
$Top1_{t-1}$	0.0004	−0.0023
	(1.46)	(−0.60)
$Top10_{t-1}$	−0.0007***	0.0044
	(−3.62)	(1.47)
Age_{t-1}	0.0765***	0.4240
	(3.10)	(1.54)
HHI_{t-1}	−0.1400	5.6819***
	(−1.26)	(2.79)
HHI_Square_{t-1}	0.2344	−12.9221*
	(0.61)	(−1.92)
Intercept	3.5361***	0.7191
	(60.79)	(0.46)
Year FE	YES	YES
Firm FE	YES	YES
R-squared	0.895	0.347
Observations	8,038	8,038

Note(s): This table reports the results of examining the channels of trade protection on firm innovation. In Column (1), the intermediary variable is regressed on the basic independent variable and control variables. In Column (2), the dependent variable is regressed to the basic independent variable, the intermediary variable and control variables at the same time. I estimate the mediating effect of financial constraint. The dependent variable is *Pat*. *SA index* is a relative measurement of reliance on external financing constructed based on Hadlock and Pierce (2010). Variables are defined in Table A1. The dependent variables are measured in year t and other variables are measured in year $t-1$. The regressions include firm and year fixed effects. T-statistics based on robust standard errors clustered at the firm level are in parentheses. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively

Table 10. Trade protection and firm innovation: possible economic mechanism

significance test at the 5% level, indicating that financial constraint reduces the effect of trade protection on firm innovation. This shows that the relaxation of financial constraint is conducive to the promotion of corporate technological innovation, which is consistent with the previous theoretical analysis.

6.7 Discussion

In this section, I find a significant increase in the number of patents applications and patent citations for firms affected by trade protection relative to other firms. Meanwhile, the results also indicate that this effect is stronger in non-SOEs. Moreover, the results also demonstrate that the provision of financing needs appears to be underlying economic channel through which trade protection encourages innovation.

Drawing on firm-level data, recent studies show that international trade can promote innovation by either intensifying competition or enlarging access to foreign markets (Liu and Ma, 2020). Coelli *et al.* (2022) provide evidence that trade liberalization encourages firms' patent filings. Unlike these studies, this paper uses Chinese data and finds that after facing trade protection from domestic governments, the financial constraint of domestic firms will relax, which in turn promotes their innovation.

This study contributes to the existing literature in terms of theory. First, I shed light on the impact of international trade on firm innovation. Several studies have found a positive and significant impact of antidumping protection on domestic productivity (e.g. Crowley *et al.*, 2018). Complementing these studies, this paper investigates the impact of trade protection on firm innovation, and the results show a positive relationship. Second, this study also contributes to the literature on the impact of trade policy uncertainty on financing constraints. Based on financial constraint theory, when the financing constraints faced by firms are eased, banks will adopt more lenient credit policies, and therefore, such firms may increase their level of innovation (Wang *et al.*, 2021). This study shows that financial constraints ease after trade protection as the exit of foreign firms from the Chinese market propagates faster than the entry of domestic firms. Third, I add to the stream of literature on the drivers of innovation. One strand of the literature focuses on trade policy uncertainty, most of which examines whether reduced trade policy uncertainty encourages innovation. This paper differs from these prior studies in that I focus on trade protection and provide evidence that trade protection has a bright side: it promotes innovation.

This study also has clear policy implications. For policy makers, in the early stage of industry development, trade protection can be used to ease the companies' financing constraints and improve the companies' profits, which will help them concentrate their efforts, promote innovation and further develop. However, in the mid-term development of the industry, policy makers should reduce trade protection. Through the entry of foreign capital, companies face increased competition, which can enhance the companies' motivation for long-term development.

For practitioners, they should seize the dividends of national policies. In the process of implementing trade protection, they should concentrate their effort on improving their innovation level and enhancing their core competitiveness. When they are not subject to trade protection, they can also make profits and develop in the long run.

7. Conclusion

In this paper, I study the link between trade protection and companies' technological innovation. Using a large sample of Chinese A-share manufacturing companies from 2003 to 2019, I show that trade protection significantly increases reference firms' innovation output measured by the number of patents applications and citations. These results are robust to a variety of tests on model specifications, variable definitions, sample selection and endogeneity issues. I also present evidence on the possible economic mechanism through which trade protection spurs innovation: relaxation of financial constraint. After a trade protection policy is adopted by Chinese government, foreign firms will exit Chinese market in response to increasing tariff. As a result, the profit of domestic firms will increase, and domestic firms face to lower financial constraint, which is the possible mechanism we identify.

Previous literature shows that international trade can promote innovation by either intensifying competition by reducing markups, generating tougher firm selection and increasing the aggregate productivity level or enlarging access to foreign markets (Coelli *et al.*, 2022; Impullitti and Licandro, 2018; Liu and Ma, 2020). Different with these studies, I find different results with the data of China, which shows that an increase in trade protection induces innovation among Chinese listed firms. I believe that the reason for this result is that Chinese enterprises are facing serious financing constraints. In the process of trade protection, the profits are increased, which can effectively ease their financing constraints and promote innovation.

Based on the sample of China, this study finds a robust and positive relationship between trade protection and firm innovation. However, this study also has its limitations. First, I only use Chinese data, and for the robustness of the empirical results, international data can be used in the future to verify whether the finding is robust internationally or only in emerging countries. Second, I only explore the impact of trade protection on firm innovation, and in the future, I can study its impact on other firm operating characteristics. I leave more applications of trade protection in corporate finance for future research.

Notes

1. Data Source: China Securities Market and Accounting Research (CSMAR) database.
2. Data Source: World Intellectual Property Organization.
3. In the year of 2019, the number of patent applications of the whole listed firms in China reached 180,527, of which 127,713 were filed by the manufacturing industries (accounted for 71%, ranked 1st in all the industries).

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(The Appendix follows overleaf)

Appendix

Variable	Definition
Pat	The natural logarithm of one plus the number of patents applied by the firm
Sub	The natural logarithm of one plus the number of substantive patents applied by the firm
Str	The natural logarithm of one plus the number of strategic patents applied by the firm
GrantPat	The natural logarithm of one plus the number of patent applications filed (and eventually granted) by the firm
GrantSub	The natural logarithm of one plus the number of substantive patent applications filed (and eventually granted) by the firm
GrantStr	The natural logarithm of one plus the number of strategic patent applications filed (and eventually granted) by the firm
Citation	The natural logarithm of one plus the citations number of a patent applied by the firm
Protection	The natural logarithm of one plus the number of trade protection cases, which the firm in the industry receives
Leverage	Long-term debt normalized by total assets
Fix	Net fixed assets normalized by total assets
ROA	Return on assets, measured as earnings before interest, tax, depreciation and amortization (EBITDA) normalized by total assets
Cash	Cash and short-term investments normalized by total assets
Size	The natural logarithm of total assets
Tobin's Q	Market value of equity plus net debt divided by the book value of total assets
*Top*1	Percentage of the stock's shares outstanding owned by the biggest investor
*Top*10	Percentage of the stock's shares outstanding owned by the top ten investors
Age	The natural logarithm of one plus the number of years since a firm's Initial Public Offering (IPO)
HHI	Herfindahl index of the industry where firm belongs based on sales
PPI	Producer Price Index
SA Index	SA index is a relative measurement of reliance on external financing constructed based on Hadlock and Pierce (2010). SA index is usually negative, and larger absolute value means more severe financial constraints

Table A1.
Variable definitions

Corresponding author
Tao Huang can be contacted at: ht@email.cufe.edu.cn