Economic Policy Uncertainty, Financing Constraints and Firm Innovation in China

Based on Experimental Analysis

Gong Chen[1], Huiyue Liu[2]
[1]First author: 2019054141@stu2019.jnu.edu.cn
[2] Corresponding author: liu_hy@sz.jnu.edu.cn

Shenzhen Tourism College, Jinan University, Shenzhen, China

Abstract—China is comprehensively deepening its reform and opening policy and implementing innovation-driven development strategies. It is very important to study economic policy uncertainty (EPU) and firm innovation over the past year of policy's implementation to learn from experience to help policies reform in future. This paper based on data of China-listed A-shares for 2000 to 2019, through experimental analysis, tests the nonlinear "inverted U" relation between EPU and firm innovation and selects two typical years as boundaries to divide the data into three samples to study the difference in the relation between EPU and firm innovation among three samples at different EPU levels. The selection of boundary years according to the financial crisis in 2008 and multiple reforms in China and the turbulent international environment in 2016. The results show that EPU promotes firm innovation at a low EPU level and inhibits innovation at a high EPU level. The significance of financing constraints is gradually increasing. In addition, the paper proves the nonlinear "inverted U" relation between EPU and firm innovation.

Keywords-EPU; Financing Constraints; Firm Innovation

1. INTRODUCTION

More than 40 years have passed since China's reform and opening up. Over these 40 years, because the economic cycle is objective, the Chinese government had to continuously adjust its economic policies to adapt to the economic cycle and achieve steady and sustainable economic growth. At the same time, with the deepening of China's domestic reform, foreign financial crises and risk contagion are also impacting China's economy. To resist these risks, the Chinese government will make economic policy adjustments. The government needs time to respond to economic fluctuations and financial crises, so there will be a time lag in policy making, resulting in economic policy uncertainty over the course of policy change. In addition, the feedback of microlevel subjects such as firms to economic policies also introduces great uncertainty into the process of policy implementation and adaptation, creating uncertainty in the process of economic policy implementation. For firms, a stable economic policy environment is conducive to all forms of production and operation activities. In contrast, a high-frequency change of economic policy will increase the cost to firms of adapting to new economic policies, increase information asymmetry, and have a great impact on firm innovation. China is constantly

ICEMME 2022, November 18-20, Nanjing, People's Republic of China

DOI 10.4108/eai.18-11-2022.2326907

deepening its reform and opening up policy and is also greatly encouraging Chinese firms to perform more innovation activities to contribute to "intelligent manufacturing in China". Exploring the impact of economic policies on firm innovation through the process of reform and opening up is conducive for the government, as this can help the government more comprehensively consider economic policy-making and policy reform.

The contributions of this paper are as follows. First, we analyse the difference in the relation between EPU and firm innovation under different EPU levels. Then, we test the nonlinear "inverted U" relation between EPU and firm innovation and analyse the possible causes of the "inverted U-shaped" relation. Finally, we prove that there is an "inverted U-shaped" relation between financing constraints and firm innovation and further explain that the relationship between EPU and firm innovation is not a simple "inverted U-shaped" relation.

2. LITERATURE REVIEW

EPU and firm innovation have gradually become major focuses of academic research in recent years. EPU refers to the uncertainty of economic policy change. With deepening research on EPU, the uncertainties of economic policy change and of economic policy implementation have generally been considered. Studies on economic policy focus on a single policy's economic effect and discuss economic theories' impact on policies before the development of a steady EPU index. For example, Dobrescu et al. (2012) reviewed the most important economic theories of the past 40 years and analysed their impact on economic policy. Because there is no relatively reliable measurement for EPU with which to perform further academic analysis, there is little research on EPU before 2013. After Baker et al. (2013) developed robust indicators to measure EPU, academic circles began to research the impact of EPU on entities in the market, and research on EPU increased rapidly after 2013. A considerable number of studies present economic policy uncertainty indexes suitable for different countries according to the method given by Scott R. Baker et al. (2013) in addition to discussions on EPU's impacts on market entities. Huang et al. (2019) developed a monthly index of EPU for China for 2000–2018. Research on EPU's impacts on market entities, such as Scarcioffolo et al. (2021), suggests that EPU increases the probability of agitated market conditions of oil and natural gas markets. The measurement of China's economic policy uncertainty involves distinguishing and identifying keywords from paper media, but Baker et al. (2013) constructed an index from English newspaper The South China Morning Post of Hong Kong, and the index cannot accurately reflect the state of China's EPU. The EPU index for China constructed by Davis et al. from Guang Ming Daily and The People's Daily published in Chinese is given in their unpublished research. The index jointly released by the University of Chicago and Stanford University can be downloaded obtained from the corresponding website (http://www.policyuncertainty.com). Hao et al. (2016) first studied the relation between EPU in China and firm innovation based on real options theory using the robust EPU index given by Baker et al. (2013). The authors argue that EPU plays a negative role in the innovation activities of firms with low financing constraint levels and have initiated further research on EPU, firm innovation and financing constraints in Chinese academic circles. In subsequent research, Gu et al. (2018) argued that EPU will promote R&D investment and patent applications of listed companies, which means that EPU has a positive impact on the innovation investment of firms. Academic circles hold two different views on the impact of EPU on firm innovation. Research on EPU and firm innovation has since

focused on the discussion of firm capital structure, executive influence, financing constraints' impacts, etc. in relation to EPU and firm innovation. All conclusions have shown that the impact of EPU on firm innovation is positive or negative. Zheng et al. (2018) found that while high-tech firms that maintain financial flexibility can help improve innovation performance to high EPU levels, this does not occur in other firms. Gu and Zhang (2019) found that an increase in labour costs has a significant selective inhibiting effect on firm innovation when EPU changes substantially. In recent work, Cheng et al. (2021) argue that the relation between economic policy uncertainty and firm innovation is not a simple promoting or inhibiting effect but presents a nonlinear "inverted U-shaped" relationship. This conclusion was tested by Yan and Shi et al. (2021). Researchers have started to find that differences exist at different EPU levels. Guan et al. (2021) argued that on the whole, EPU is positively related to a company's technological innovation but negatively related to a company's business model innovation, expanding the scope of firm innovation. The authors believe that market competition can promote firm innovation under high levels of EPU. Lou et al. (2022) found a negative correlation between EPU and firm innovation output and argued that this negative correlation exists in firms with low risk-taking preferences and abilities. The authors also found firm innovation to have a strong positive impact on firm value at low EPU levels.

According to the above research, this paper finds a relation between the different levels of economic policy uncertainty and firm innovation. The samples of the above studies are distributed across different segments from 1999 to 2017. According to China's EPU index jointly released by Stanford University and the University of Chicago, as shown in Figure 1, the EPU index changed by approximately 50 points before 2007, while after the financial crisis in 2008, China's EPU index changed by approximately 100 points and nearly doubled from 2008 to 2016 compared the change from 2000 to 2017. In 2016, after China's domestic "replacing business tax with value-added tax" supply-side structural reform and real estate restrictions and after changes to the international situation, RMB joined SDR and a trade war occurred, and EPU values for 2017 to 2019 changed greatly and rose to approximately 350. Therefore, it is necessary to consider all data for 2000 to 2019 in the research scope to discuss the impact of different EPU levels on firm innovation.

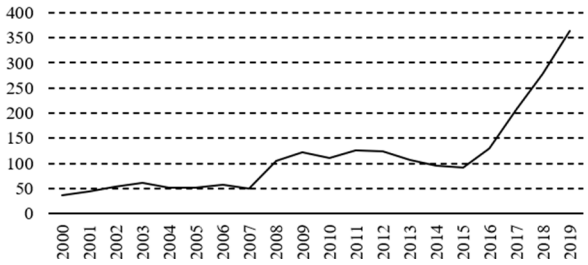

Figure 1. Chinese EPU index for 2000 to 2019

Financing constraints are explored throughout the research on EPU and firm innovation. Kaplan and Zingales (1997) provide a general definition for financing constraints: the differences in internal and external financing costs caused by information asymmetry and external financing costs that are often higher than internal financing costs, resulting in "constraints". The authors also propose a method for measuring financing constraints: the KZ index. Whited and Wu (2006)

constructed a WW index related to a firm's external financing constraints. Hadlock and Pierce (2010) questioned the effectiveness of the KZ index and WW index and constructed a new index to measure financing constraints based on firm size and firm age: the SA index. The SA index is negative, and the authors believe that the larger the SA index is, the greater the financing constraints the firm faces are. Financing constraints usually play a mechanistic role in research on firm innovation and often serve as intermediary variables or regulatory variables to explain the other variables' impacts on firm innovation. Zhao et al. (2020) argued that financing constraints play an intermediary effect between EPU and firm innovation. Cheng et al. (2021) also used the SA index to confirm that financing constraints play a regulatory role between EPU and firm innovation; however, both of these works only discuss financing constraints' negative effects on firm innovation. Ding and He (2019) discussed the impact of EPU on firm innovation under different levels of financing constraints and argued that financing constraints have a significant nonlinear relation to a company's R&D investment and the number of patent applications. Different financing constraints have different impacts on a company's R&D investment and patent applications in opposite ways.

According to the above research, financing constraints play an intermediary and regulatory role between EPU and firm innovation, and there is a nonlinear "inverted U-shaped" relation between EPU and firm innovation. Therefore, it is necessary to identify whether the "inverted U-shaped" relationship between EPU and firm innovation is caused by financing constraints. That is, there is an "inverted U-shaped" relation between financing constraints and firm innovation.

3. DATA AND MODEL

This section introduces the data, processes and variables used. Then, by modelling and regression analysis, the paper explores the problems mentioned above. The specific sections are titled Research Samples and Data Sources, Variable Definition, Descriptive statistics of variables and Model Setting.

3.1 Research Samples and Data Sources

The EPU data used for this paper are drawn from the EPU index of China jointly released by Stanford University and the University of Chicago and composed of Davis, Liu and Sheng. The data come from http://www.policyuncertainty.com. Data on companies are also obtained from China's CSMAR database. Annual panel data of China's listed A-share firms for 2000 to 2019 are selected as the research sample. ST shares are excluded, and company samples with a serious lack of data are removed.

3.2 Variable Definition

Three types of variables are used in this paper, as shown in Table 1. The specific variable definitions are as follows:

Number of patent applications (*Apply*): The main variables for measuring firm innovation are firm innovation investment intensity (R&D) and the number of firm patents. To expand the sample time span, this paper takes the number of firm patents as the index of firm innovation. Compared to the authorized patent, the patent application can better reflect the firm innovation

output. Because the patent application may have a value of zero, the logarithm is taken after adding one to the number of patent applications for standardization. The more patent applications there are, the stronger the level of firm innovation is.

Economic policy uncertainty index (*EPU*): China's EPU index was composed by Davis et al. with the methods of Baker et al. using data from The People's Daily and Guang Ming Daily reported in Chinese. Data on China's EPU index are obtained from http://www.policyuncertainty.com. According to the method for composing the index, the higher the EPU index is, the stronger more uncertain economic policy is. Financing constraints (*SA*): From the total assets and age of a firm determined from the Chinese CSMAR database, the SA index of financing constraints can be calculated by the method of Hadlock and Pierce (2010). According to the method described in Hadlock and Pierce (2010), the SA index is negative, and the larger the SA index is (the closer it is to zero), the stronger the financing constraint of a firm is. Control variables (*Control*): Based on the above research on EPU, financing constraints and firm innovation, five main control variables are selected as shown in Table 1. This paper uses total assets to control firm scale (*Asset*), the equity multiplier to control capital structure (*Equity*), the asset liability ratio to control firm leverage (*Lev*), return on assets to control firms' operation status (*ROA*), and firm cash flow to control firms' payment and repayment ability (*Cash*). To reflect differences between variables, the total assets and cash flow of firms are multiplied by 10^-9, and the differential process is used to standardize the variables. The equity multiplier (*Equity*) is equal to 1/(1-asset liability ratio), the asset liability ratio (*Lev*) is equal to total liabilities/total assets, and firms' operation status (*ROA*) is equal to the after tax net profit/total assets.

TABLE 1. VARIABLE NAMES AND DESCREPTIONS

Variable Type	Variable Name	Variable Meaning	Variable Interpretation
Explained Variable	*Apply*	Firm innovation	ln(Number of firm's patent applications + 1)
Explanatory Variable	*EPU*	EPU	Index composed by Davis, Liu and Sheng
	SA	Financing constraints	Index composed by Hadlock and Pierce
Control Variable	*Asset*	Total asset	Total asset*10^-9 and differential process
	Equity	Equity multiplier	1/(1-Asset liability ratio)
	Lev	Asset liability ratio	Total liabilities / total assets
	ROA	Return on total assets	Net profit after tax / total assets
	Cash	Cash flow	Cash flow*10^-9 and differential process

3.3 Descriptive statistics of variable

The descriptive statistics of each variable are shown in Table 2. According to Table 2, the mean

value of explanatory variable Apply is 0.645, and the standard deviation is 0.761, indicating that there are great differences in innovation ability among firms. The EPU changes greatly from 2000 to 2019 with a mean value of 119.362, a standard deviation of 82.661, a mean value of financing constraints of -3.671 and a standard deviation of 0.287. Each explanatory variable shows a significant difference.

TABLE 2. DESCREPTIVE STATISTICS OF EACH VARIABLE

Variables	Maximum value	Minimum value	Mean	Standard deviation
Apply	4.017	0	0.645	0.761
EPU	363.359	35.567	119.362	82.661
SA	-2.563	-4.470	-3.671	0.287
Asset	2.580	-0.979	0.054	0.138
Equity	532.925	0.837	2.688	7.569
Lev	1.049	-0.195	0.487	0.197
ROA	20.788	-0.999	0.040	0.249
Cash	85.890	-63.027	0.0287	2.796

3.4 Model Setting

According to Figure 1 and China's EPU index for 2000 to 2019, to study differences in the EPU level's impact on firm innovation and financing constraints, the sample is divided into three subsamples by year: Group A covers 2000-2007; Group B covers 2008 to 2015; and Group C covers 2016-2019. The three groups were bonded by 2008, when the global financial crisis occurred, and 2016, when China's important policy reforms, such as Business Tax Replaced with VAT, supply side structural reform and real estate restrictions, also occurred in a complex international environment.

This paper presents a difference analysis to study the relations among EPU, financial constraints and firm innovation based on different EPU levels of the three samples. The 2000-2007 period, which involved steady development, is representative of lower EPU levels. From 2008 to 2015, the government continued to stimulate economic development after the 2008 financial crisis, rendering this period representative of moderate and high EPU levels. The period of 2016 to 2019, with domestic reforms and drastic changes in the international environment and with the impact of IMF added the RMB to the basket of currencies that make up the Special Drawing Right and the trade war between China and the United States, is representative of high EPU levels and considerable change. To study how EPU levels shape the impact of EPU on firm innovation, the impact of EPU on financing constraints and firm innovation and the "inverted U" relation between EPU and firm innovation, Models I and II are applied.

Model I set as fellows. $\sum Control$ is an aggregate of all control variables, ε is the perturbation term, i represents a single firm, t represents a single year, μ_i is the individual fixation effect,μ_t is the time fixed effect. All variables lag to the first order to address endogeneity problems.

Model I:

$$Apply_{i,t-1} = EPU_{t-1} + \sum Control_{i,t-1} + \varepsilon_{i,t-1} + \mu_i + \mu_{t-1} \quad (1)$$

$$Apply_{i,t-1} = EPU_{t-1} + SA_{i,t-1} + \sum Control_{i,t-1} + \varepsilon_{i,t-1} + \mu_i + \mu_{t-1} \quad (2)$$

$$Apply_{i,t-1} = EPU^2_{t-1} + EPU_{t-1} + \sum Control_{i,t-1} + \varepsilon_{i,t-1} + \mu_i + \mu_{t-1} \quad (3)$$

To further study the "inverted U" relation between EPU and firm innovation, this paper discusses whether there is also an "inverted U" relation between financing constraints and firm innovation through Model II. By adding the secondary item of SA in (2) to separately analyse the impact of financing constraints on firm innovation, EPU is added in (4). Model II is set as follows. The meanings of other variables are the same as those of Model I. Similarly, to address endogeneity, all variables lag by one order.

Model II:

$$Apply_{i,t-1} = SA^2_{i,t-1} + SA_{i,t-1} + \sum Control_{i,t-1} + \varepsilon_{i,t-1} + \mu_i + \mu_{t-1} \quad (4)$$

$$Apply_{i,t-1} = EPU_{t-1} + SA^2_{i,t-1} + SA_{i,t-1} + \sum Control_{i,t-1} + \varepsilon_{i,t-1} + \mu_i + \mu_{t-1} \quad (5)$$

4. Empirical Research Results and Analysis

The LM, LR and Hausman tests of two models reject the original hypothesis and show that the fixed effect model is the optimal estimation method. After further heteroscedasticity tests and Wooldridge tests, heteroscedasticity and sequence correlations were considered. Because the years of firm establishment are different, an unbalanced panel is used. The new Pesaran (2015) method is used to test the cross-sectional correlation of the weakly balanced panel for the explanatory and explained variables. This test also rejects the original hypothesis and identifies cross-sectional correlation. Therefore, Models I and II use the robust standard error of "heteroskedasticity and contemporaneous and lagged spatial correlation" proposed by Driscoll and Kraay (1998) to estimate the model.

4.1 Differences in Different EPU Level Analysis (Model I).

During regression, it is found that time dummy variables and constants are collinear. To distinguish whether this is because of a serious collinearity problem between variables, the variance expansion coefficient is calculated. As shown in Table 3, the VIF coefficients of the variables are far less than 10 (control variables included in the mean VIF), indicating that there is no serious collinearity problem among the variables. To ensure that the constants are not collinear except for the key time points that may have a great impact on EPU such as 2008 and 2016, some time dummy variables are removed to avoid collinearity.

TABLE 3. VIF Coefficient of Variables

Variable	VIF
SA	1.52
EPU	1.52
Mean VIF	1.25

The difference analysis results for different EPU levels are shown in Tables 4~7. Overall, EPU promotes firm innovation; at a low EPU level, EPU promotes firm innovation; and at a high

EPU level, EPU inhibits firm innovation. However, after EPU^2 is added, EPU promotes firm innovation. The negative coefficient of EPU^2 shows that an "inverted U-shaped" relation between EPU and firm innovation does not exist, which is consistent with the conclusions of Cheng (2021). The impact of financing constraints on firm innovation is no longer significant in the subsamples, but the t value of SA at the low EPU level is far less than that at the high EPU level, which means that the impact of SA on firm innovation at the high EPU level is stronger than that at the low EPU level.

TABLE 4. RESULTS OF SAMPLE A, MODEL I [a]

Sample		**a (low EPU level: 2000~2007)**		
Model I		(1)	(2)	(3)
Explanatory variable	*EPU*	0.00222*** (11.15)	-0.01683*** (-7.85)	0.26445*** (56.51)
	SA		0.11514 (0.95)	
	EPU^2			-0.00253*** (-57.93)
Control variable	*Asset*	0.03966 (0.60)	0.05250 (0.70)	0.03966 (0.60)
	Equity	-0.00037 (-0.33)	-0.00044 (-0.39)	-0.00037 (-0.33)
	Lev	0.11037* (1.95)	0.12171** (2.55)	0.11037* (1.95)
	ROA	0.18938* (2.25)	0.19492* (2.23)	0.18938* (2.25)
	Cash	-0.02070 (-1.22)	-0.01921 (-1.17)	-0.02070 (-1.22)
Entity fixed effects	μ_i	Yes	Yes	Yes
Time fixed effects	μ_t	Yes	Yes	Yes
Constant term	*Cons*	0.03609 (1.89)	-0.85307*** (-4.40)	-6.60052*** (-60.28)
Observation	*N*	2788	2788	2788
Variance	R^2	0.0644	0.0645	0.0644

a. Note: The coefficients in parentheses are t value; ***, **, * respectively indicate that the estimated values of the parameters are significant at 1%, 5% and 10% of the statistical level, the same below.

TABLE 5. RESULTS OF SAMPLE B, MODEL I

Sample	**b (Medium EPU level: 2008~2015)**			
Model I		(1)	(2)	(3)
Explanatory variable	*EPU*	-0.00583*** (-69.04)	-0.00532*** (-8.51)	-0.01517*** (-18.38)
	SA		-0.09996	

			(-0.82)	
	EPU^2			0.00004*** (11.41)
Control variable	*Asset*	0.15228*** (5.43)	0.13977*** (4.09)	0.15228*** (5.43)
	Equity	0.00067 (1.21)	0.00070 (1.26)	0.00067 (1.12)
	Lev	0.24160*** (4.67)	0.24222*** (4.71)	0.24160*** (4.67)
	ROA	0.17047 (1.06)	0.16538 (1.03)	0.17047 (1.06)
	Cash	0.00210 (0.78)	0.00202 (0.74)	0.00210 (0.78)
Entity fixed effects	μ_i	Yes	Yes	Yes
Time fixed effects	μ_t	Yes	Yes	Yes
Constant term	*Cons*	1.33320*** (60.08)	0.89938 (1.72)	1.82972*** (57.87)
Observation	*N*	4133	4133	4133
Variance	R^2	0.1613	0.1615	0.1613

TABLE 6. RESULTS OF SAMPLE C, MODEL I

Sample	**c (High EPU level: 2006~2019)**			
Model I		(1)	(2)	(3)
Explanatory variable	*EPU*	-0.00073*** (-77.72)	-0.00064*** (-12.80)	0.00474*** (50.19)
	SA		0.22802 (1.83)	
	EPU^2			-0.00001*** (-59.83)
Control variable	*Asset*	0.11181 (1.64)	0.11192 (1.66)	0.11181 (1.64)
	Equity	0.00147 (1.56)	0.00147 (1.55)	0.00147 (1.56)
	Lev	0.08380 (1.55)	0.08008 (0.53)	0.08381 (0.55)
	ROA	0.33369 (1.17)	0.33198 (1.16)	0.33369 (1.17)
	Cash	-0.00254 (-1.29)	-0.00267 (-1.31)	-0.00253 (-1.29)
Entity fixed effects	μ_i	Yes	Yes	Yes
Time fixed effects	μ_t	Yes	Yes	Yes

Constant term	*Cons*	1.0556*** (13.99)	1.93591*** (4.64)	0.53280*** (7.95)
Observation	*N*	2123	2123	2123
Variance	R^2	0.1501	0.1501	0.1501

TABLE 7. RESUTS OF ALL, MODEL I

Sample	**all (Medium EPU level: 2000~2019)**			
Model I		(1)	(2)	(3)
Explanatory variable	*EPU*	-0.00583*** (-69.04)	-0.00532*** (-8.51)	-0.01517*** (-18.38)
	SA		-0.09996 (-0.82)	
	EPU^2			0.00004*** (11.41)
Control variable	*Asset*	0.15228*** (5.43)	0.13977*** (4.09)	0.15228*** (5.43)
	Equity	0.00067 (1.21)	0.00070 (1.26)	0.00067 (1.12)
	Lev	0.24160*** (4.67)	0.24222*** (4.71)	0.24160*** (4.67)
	ROA	0.17047 (1.06)	0.16538 (1.03)	0.17047 (1.06)
	Cash	0.00210 (0.78)	0.00202 (0.74)	0.00210 (0.78)
Entity fixed effects	μ_i	Yes	Yes	Yes
Time fixed effects	μ_t	Yes	Yes	Yes
Constant term	*Cons*	1.33320*** (60.08)	0.89938 (1.72)	1.82972*** (57.87)
Observation	*N*	4133	4133	4133
Variance	R^2	0.1613	0.1615	0.1613

The results above show that the inhibition of EPU through firm innovation is related to the "inverted U" relation between EPU and firm innovation, and the role of financing constraints is strengthened with an increase in EPU. These results along with the other results described above show that EPU will indeed lead firms to increase innovation investment, but the level of financing constraint limits the sustainability of EPU's promotion of firm innovation. An increase or decrease in financing constraints will change the level of restriction, causing the inflection point of innovation investment to shift from increasing to decreasing. If EPU continues to increase, firm innovation will also continue to decline due to the strengthening of financing constraints caused by EPU. This is one of the reasons for the "inverted U" relation between EPU and firm innovation.

4.2 Test on The "inverted U" Relation (Model II)

During regression, it is found that the time dummy variables are collinear, and as was done for the operation in Model I, some time dummy variables leading to collinearity are removed. The data in Table 8 show that there is indeed a nonlinear "inverted U-shaped" relation between financing constraints and firm innovation. Financing constraints play an intermediary and regulatory role between EPU and firm innovation, and they also have an "inverted U-shaped" relation to firm innovation, which explains why different data samples lead to different conclusions on the role between EPU and firm innovation and which also explains the anomaly of the coefficient of EPU^2 in sample b, Model I. In addition, in Model I, the coefficient of financing constraints is positive, but in Model II, the quadratic term is separately removed from SA and becomes negative, indicating that the "inverted U-shaped" relation between financing constraints and firm innovation also interferes with the effect of financing constraints on firm innovation. In Model II, after removing the financing constraint and secondary term from EPU, EPU has a negative impact on firm innovation. According to the results of Model I, after removing the secondary term of EPU, the EPU coefficient becomes positive, indicating that the nonlinear impact of EPU on firm innovation is not only attributable to the financing constraint.

TABLE 8. RESULTS OF MODEL II

Model II		**(4)**	**(5)**
Explanatory variable	*EPU*		-0.00052*** (-11.47)
	SA	-1.83699*** (-4.74)	-1.83699*** (-4.74)
	SA^2	-0.28879*** (-5.61)	-0.28879*** (-5.61)
Control variable	*Asset*	0.08451** (2.22)	0.08451** (2.22)
	Equity	-0.00061 (-0.68)	-0.00061 (-0.68)
	Lev	0.26618*** (10.04)	0.26618*** (10.04)
	ROA	0.14329 (1.73)	0.14329 (1.73)
	Cash	-0.00316 (-1.56)	-0.00316 (-1.56)
Entity fixed effects	μ_i	Yes	Yes
Time fixed effects	μ_t	Yes	Yes
Constant term	*Cons*	-1.89449** (-2.44)	-1.82745** (-2.36)
Observation	*N*	9044	9044
Variance	R^2	0.3086	0.3086

5. CONCLUSION

This paper takes A-share listed companies of 2000 to 2019 as a research sample; firm innovation as an explained variable; and financing constraints and EPU as explanatory variables. To expand the sampled time span, firm patent application is taken as an index to measure firm innovation. Meanwhile, firms' total asset scales, equity multipliers, asset liability ratios, returns on total assets and cash flows are used as control variables. To perform a difference analysis of different EPU levels, the years 2008, when the financial crisis affected the world, and 2016, when important economic events such as the replacement of business tax with VAT occurred, as boundaries. Different EPU levels are divided according to the EPU levels of three samples to perform a difference analysis. In addition, the relation between financing constraints and firm innovation is explored.

From the above empirical analysis, the following conclusions are drawn: at a low EPU level, EPU promotes firm innovation; at a high EPU level, EPU inhibits firm innovation, and the role of financing constraints at a high EPU level is stronger than that at a low EPU level. After removing the secondary term of EPU, EPU promotes firm innovation. There is an "inverted U-shaped" relation between EPU and firm innovation. By further testing the relation between financing constraints and firm innovation in Model II, it is proven that there is also an "inverted U-shaped" relation between financing constraints and firm innovation. According to previous studies, financing constraints have intermediary and regulatory effects between firm innovation and EPU, but the "inverted U" relation between financing constraints and firm innovation also has an effect. The "inverted U-shaped" relation between EPU and firm innovation is attributable to the restriction and inhibition of financing constraints and to the "inverted U-shaped" relation between financing constraints and firm innovation. The complexity of such relations leads to different conclusions on the relation between EPU and firm innovation for different samples and EPU levels.

There are two measurements of firm innovation: patent application and R&D investment. To expand the sample time span, firm patent application is selected as the measure of firm innovation in this paper. The research of Ding and He (2019) shows that the effect of EPU on firm patent applications and R&D investment varies. When conducting research on firm innovation, it is necessary to study the difference between the input intensity of firm innovation (R&D investment) and the output of firm innovation (firm patent application).

Acknowledgement. This research was partially supported by grants from Guangdong Planning Office of Philosophy and Social Science [Grant Number GD19CLJ02] and Guangdong Provincial Science and Technology Department [Grant Number 2019A101002021]. We would like to thank the anonymous referee and the editor for very helpful and detailed comments.

REFERENCES

[1] Baker, S. R., Bloom, N., & Davis, S. J.. (2015). Measuring economic policy uncertainty. LSE Research Online Documents on Economics.

[2] Davis, S. J., Dingquian Liu and Xuguang Simon Sheng, 2019. "Economic Policy Uncertainty in China Since 1946: The View from Mainland Newspapers", unpublished.

[3] A, Z. L., A, S. C., C, W. Y. B., E, C. Z. B. D., & A, X. Y. . (2022). Economic policy uncertainty and firm innovation: evidence from a risk-taking perspective. International Review of Economics & Finance, 77, 78-96.
[4] Guan, J. , Xu, H. , Huo, D. , Hua, Y. , & Wang, Y. . (2021). Economic policy uncertainty and corporate innovation: evidence from china. Pacific-Basin Finance Journal, 67.
[5] Kaplan, S. N. , & Zingales, L. . (1995). Do financing constraints explain why investment is correlated with cash flow?. NBER Working Papers, 112(1).
[6] Hadlock, C. J. , & Pierce, J. R. . (2010). New evidence on measuring financial constraints: moving beyond the kz index. Review of Financial Studies, 23(5), 1909-1940.
[7] Dobrescu, M. , Hristache, D. , & Iacob, S. . (2012). Recent theoretical progress in economics and its impact on economic policy. Procedia - Social and Behavioral Sciences, 62(1), 561-565.
[8] Y Huang, Luk, P. , Fleisher, B. M. , Huang, K. , Lovely, M. E. , & Y Wen, et al. Measuring economic policy uncertainty in china. China Economic Review, 59.
[9] Ars, A. , & Xle, B. . (2021). Regime-switching energy price volatility: the role of economic policy uncertainty. International Review of Economics & Finance.
[10] Driscoll, J. C. , & Kraay, A. C. . (1998). Consistent covariance matrix estimation with spatially dependent panel data. The Review of Economics and Statistics, 80(4), 549-560.
[11] Anselin, L. , Gallo, J. L. , & Jayet, H. . (2008). Spatial Panel Econometrics. Springer Berlin Heidelberg.
[12] Cheng Liwei, Zhao Yanchen & Wu Wei. (2021). Economic policy uncertainty, financing constraints and enterprise R & D Investment -- Based on panel data of enterprises in 20 countries (regions). Scientific research (02), 244-253.
[13] Zhao Meng, Ye Li & fan Honghui. (2020). Economic policy uncertainty and manufacturing enterprise innovation -- A Study on the intermediary effect of financing constraints. East China Economic Management (01), 49-57.
[14] Zheng qionge, Lei Guoquan & Xu Anxin. (2018). Empirical Study on economic policy uncertainty, financial flexibility and enterprise innovation performance. Statistics and decision making (18), 164-167.
[15] Gu Xiaming, Chen Yongmin & pan Shiyuan. (2018). Economic policy uncertainty and Innovation -- An Empirical Analysis Based on Listed Companies in China. Economic Research (02), 109-123.
[16] Ding Xin & he Yiqing. (2019). Environmental regulation, financing constraints and technological innovation: inhibition or promotion—— Research on heterogeneity based on regulatory effects. (eds.) proceedings of the 14th (2019) China Management Annual Conference (pp. 166-182).
[17] Yan Fulei & Shi Yiming. (2021). Economic policy uncertainty, financial development and enterprise innovation. Financial Development Research (05), 18-26.
[18] Geng yeqiang & Guo Wei. (2021). Economic policy uncertainty, R & D investment and enterprise labor productivity. Economic issues (09), 53-63.