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Corporate trade war uncertainty and patent bubble

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Abstract

This paper draws upon resource dependence theory and investigates how trade policy uncertainty affects firm strategic innovation management in China. Adopting a machine learning approach called *Word2Vec* from computational linguistics, we construct and validate a measure of firm-level managers' perceived trade war uncertainty (TWU). We find that TWU has a positive effect on the number of total patent applications, but this positive effect is totally driven by low-quality patents instead of high-quality patents. Moreover, we document that firms have stronger incentives for such strategic innovation behavior when the underlying firms are more financially constrained, and/or when the management is more myopic. In addition, we open the behavioral black box of firms' strategic innovation and demonstrate that patents can be employed opportunistically to meet government policies to further attract more government subsidies.

Keywords

Trade War Uncertainty, Strategic Innovation Management, Patent Bubble, Machine Learning

Introduction

The year 2018 witnessed the outbreak of an escalating global trade war with the prime battlefront being the commercial relationship between the United States and China. On the one hand, to actively deal with the policy uncertainty generated by trade wars, the Chinese government implements a national innovation strategy to increase support for firm innovation by providing innovation subsidies and introducing a series of preferential policies (e.g., tax preference). On the other hand, China-based firms claim that the trade war stimulates their national morale to foster innovation activities and motivates awareness to realize independent innovation[1]. However, faced with high policy uncertainty stemming from trade wars, will firms really innovate to improve competitive advantages? Or will they strategically pursue innovation by quantity instead of quality to cater to the government's demand?

Government funds firms to encourage innovation activities in most countries (Guo et al., 2016). Such government actions are motivated by an underlying assumption that high-quality innovation activities with considerable technological returns dominate firm innovation output (Brav et al., 2018). However, firms may not only substantively innovate to promote competitiveness and technological progress, but also strategically innovate to obtain opportunistic benefits (Tong et al., 2014). A typical strategic innovation strategy is to pursue innovation quantity to meet government policy requirements in order to receive government subsidies. However, there has been little discussion about firms' strategic incentives to engage in innovation behaviors under trade policy uncertainty. Understanding how policy uncertainty derived from

[1] See Financial Times at: https://www.ft.com/content/6124beb8-5724-11ea-abe5-8e03987b7b20.

trade wars may shape a firm's strategic innovation management has important academic implications and policy relevance, both because innovation is crucial to the national economic growth and a firm's competitiveness (Eroglu and Hofer, 2014) and because a trade war creates a high degree of policy uncertainty that might force firms to re-evaluate their operations and production strategies. A thorough exploration into this research question entails a comprehensive analysis of how to address the methodological challenges in measuring managers' perceived trade war uncertainty (TWU) and how to identify firms' strategic innovation management.

In this research, taking trade war as the research context, we investigate the impact of managers' perceptions of firm-specific TWU on firm strategic innovation management. Under Chinese patent law[2], there exist three types of patents disclosed by the China National Intellectual Property Administration (CNIPA): invention patents, utility patents, and design patents. In general, invention patents are the most technologically innovative and subject to strict examination by the CNIPA, while the two other patent types involve limited technological advancements, represent small and incremental innovations, and receive limited patent examination as well as are accompanied by low production costs. Therefore, utility patents and design patents, which are often regarded as "*non-invention patents,*" offer us a useful lens through which to understand and examine firm strategic innovation behaviors.

Drawing upon resource dependence theory (Pfeffer and Salancik, 1978), we argue that managers' perceived TWU will motivate firm strategic innovation activities. Resource dependence theory suggests that a firm is not a fully autonomous organization but an open system that faces external environmental uncertainty and is dependent on external resources to survive (Pfeffer and Salancik, 1978). Although TWU may encourage the enthusiasm of firms in China to stimulate innovation activities, firms exposed to trade wars are susceptible to increased demand uncertainty (Martin and Otto, 2020), low market values, and high default risks (Huang et al., 2019), and they experience reduced long-term investments and financial profits (Benguria et al., 2022; Chen et al., 2021). What's worse, high-quality technological innovation involves substantial innovation inputs and high uncertain returns (Eroglu and Hofer, 2014). Hence, firms are more likely to depend on external resources to survive under high TWU. In other words, TWU may distort firms' innovation strategies and strengthen their engagement in strategic innovation motives (e.g., generating more low-quality patents) because those strategic innovation activities may cater to government policies and attract more government subsidies. Specifically, the Chinese government provides significant subsidies to encourage corporate innovation (Guo et al., 2016) and sets the quantity of patent applications as a principal criterion. Therefore, we hypothesize that companies have strong incentives to engage in strategic innovation activities in response to TWU via increasing the quantity of low-quality patents to receive more supporting subsidies.

To fulfill the research gap in quantifying firm-specific TWU perceived by top managers due to a lack of firm-level data, we develop and validate an instrument to measure TWU using a machine learning method called Word2Vec by learning the Management Discussion and Analysis (MD&A) section embedded in annual reports of public firms in China. To examine our predictions, we collect archival data to conduct an empirical study of 2,490 unique China-based public firms with a sample of 12,821 firm-year observations during the period 2007-2019. We find that TWU has a positive effect on the number of total patent applications and on the number of non-invention patent applications, whereas it has no marginally significant impact on the number of invention patent applications. These findings indicate a strategic innovation behavior that firms use in reaction to TWU through strategically manipulating low-quality patenting activities. Furthermore, we investigate whether or not this strategic innovation behavior is moderated by financial constraints and managerial myopia. We conjecture and document that the strategic innovation behavior is strengthened when the underlying firms are more financially constrained and/or when the management is more myopic. In addition, we open the black box of firms' strategic innovation management and confirm that firms filing for more low-quality patents are motivated to meet government policies to signal their technology to attract more future government subsidies.

Our research contributes to Accounting Information System literature by exploring firms' strategic innovation management. Our results document a patent bubble phenomenon that policy uncertainty emanating from trade wars induces top managers to strategically manipulate low-quality patenting activities to attract government supports. This study answers the thought-provoking research question on

2 See Chinese patent law at: https://www.cnipa.gov.cn/art/2020/11/23/art_97_155167.html.

why firms perform strategic innovation management and we extend it to the context in which managers perceive uncertainty.

Second, we add to a burgeoning stream of trade war literature examining the impacts of policy uncertainty stemming from macro trade wars. Whereas prior studies provide evidence on the effects of trade war on supply chain shift (Zhang, 2020), market values (Huang et al., 2019), and firm long-term investments (Benguria et al., 2022; Chen et al., 2021) we extend this line of literature by examining the operational implications of trade war uncertainty on firm-level strategic innovation management. Our study also extends previous research on environmental uncertainty arising from changes in demand or technology (Helper et al., 2021), or in macroeconomic (Wang et al., 2022).

Third, our paper is the first to address the major barrier for researchers to measure firm-specific policy uncertainty stemming from macro trade wars. We apply a machine learning approach, *Word2Vec*, to develop a text-based measure of dynamic firm-level TWU to conquer the empirical challenge. Our approach appears to provide a valid measure of managers' perceived trade war uncertainty that is distinct from broader measures used in the literature that likely reflect overall economic uncertainty, rather than firm-specific measures of uncertainty (Baker et al., 2016).

Hypotheses Development

A widely accepted view in innovation research and policy practice is that innovation has significant implications on driving economic growth, firm-level productivity, and competitiveness. However, motivating real innovation is hard for most firms (Lee and Schmidt, 2017), because innovation involves a long-term and risky process with highly uncertain returns and a low likelihood of success (Boudreau et al., 2011; Mackelprang et al., 2015). An understanding of innovation primarily relates to substantial innovation with high-quality patenting activities. Prior research, however, provides limited evidence on the economically significant strategic behavior of managers using innovation as a tool to obtain government subsidies. In fact, managers' strategic resource allocation decision plays a distinctive role in a firm's viability (Hutchison-Krupat and Kavadias, 2015; Klingebiel and Rammer, 2014).

Built on resource dependence theory, we hypothesize that TWU positively induces firm strategic innovation activities. On the one hand, policy uncertainty in international relations among countries, such as trade wars, can substantially increase a firm's dependence on external resources to survive. The U.S.-China trade war may possibly motivate the national morale of firms in China to promote innovation activities. Unfortunately, though, firms affected by trade wars decrease long-term investments (Benguria et al., 2022; Chen et al., 2021) and experience poorer stock performance and greater default risks (Huang et al., 2019). Moreover, strong market pressure results in firms' managerial myopia (Stein, 1989). Consequently, in response to TWU, firms have less motivation to engage in high-quality innovation activities that are full of uncertain returns and along with a high probability of failure (Mackelprang et al., 2015), but have strong motivation to engage in opportunistic patenting activities with relatively low production costs for the purpose of survival. On the other hand, strategic patenting activities may not help to improve a firm's competitiveness, but they can serve as a signaling device to inform outsiders that a firm's technology has developed to a certain extent (Haeussler et al., 2014). In China, government funds firms to foster innovation activities to drive economic growth (Guo et al., 2016). A patent, no matter what type it is, is an asset that can be pledged as collateral in the process of seeking government support (Guo et al., 2016). As a result, this situation distorts firms' innovation strategies and encourages them to file for more low-quality patents to meet government policies, which can further attract more government subsidies. In summary, TWU exacerbates the strategic use of patents. Therefore, we hypothesize that:

Hypothesis 1: *Managers' perceived trade war uncertainty is positively associated with a firm's strategic innovation management.*

We are also interested in understanding how the strength of the direct positive relationship between trade war uncertainty and firm strategic innovation may be moderated by firm fundamentals. One of the most critical factors may be firms' financial constraints that affect their strategic innovation motives, because financing enables firms to explore new technologies and commercialize inventions (Chang et al., 2019).

Prior research has suggested that abundant financial resources foster firm innovation, sustainable competitive advantages, and new product success (Lee and Chen, 2009). On the contrary, financial

constraints impede firm growth, reduce the chance of survival (Musso and Schiavo, 2008), and make firms re-allocate resources with respect to which innovation activities to engage in and which to give up (Galia and Legros, 2004). Furthermore, Given that patenting behavior plays a crucial role in securing financing (Graham et al., 2009), firms affected by financial resource constraints still have to patent. Thus, when facing increasing trade war uncertainty, financially constrained firms may choose to pursue strategic innovation activities since their limited financial resources don't allow them to support all technologically possible innovations. That is, firms are more likely to adapt to TWU by engaging in low-quality patenting activities that are accompanied by low production costs when they are more financially constrained. Consequently, we expect that financial constraints strengthen firms' opportunistic reactions to increased trade war uncertainty. This leads to our second hypothesis stated as follows:

Hypothesis 2: *Higher levels of financial constraints strengthen the positive effect of managers' perceived trade war uncertainty on strategic innovation management.*

The strategic response to TWU could also vary as a function of managerial myopia, because corporate innovation is most vulnerable to short-termism (Brav et al., 2018). Researchers have shown that managerial myopia leads to limited innovation activities. For example, Edmans et al. (2014) and Edmans et al. (2017) document that short-term CEOs are likely to sacrifice long-term value for the purpose of boosting short-term profits by reducing innovation investments (e.g., investment in long-term R&D projects). Other studies have also shown that managerial myopia has a negative effect on innovation (Ladika and Sautner, 2020), since firm managers can take advantage of short-term profits from the stock market (Bolton et al., 2006). As a result, faced with high TWU, myopic management are more willing to pursue short-term projects at the expense of long-term fundamental values by engaging in low-risk patenting activities, resulting in them generating fewer high-quality patents. That is, TWU encourages short-term managers to pursue strategic innovation activities. Therefore, we present:

Hypothesis 3: *Higher levels of managerial myopia strengthen the positive effect of managers' perceived trade war uncertainty on strategic innovation management.*

Methodology

Data and Sample Selection

Our sample includes all public Chinese firms listed on A-share Shanghai and Shenzhen Stock Exchanges during the period of 2007 to 2019. Our data are from several sources. We first download all annual reports from the two domestic stock exchanges during our sample window. Similar to the approach adopted by Li (2010) and Muslu et al. (2015), we subsequently extract the MD&A sections from these filings and segment each MD&A narrative into a series of sentences. Then we collect data on patent information from the CNIPA, firm fundamentals from the China Securities Markets and Accounting Research (*CSMAR*) database, and government subsidy from the WIND database. Economic policy uncertainty data are obtained from Baker et al. (2016). We eliminate firms in the financial service industry, under Special Treatment, and observations with missing data are also excluded. We further drop observations containing less than 200 words in the MD&A narrative and observations with missing data. Finally, our final sample consists of 12,821 firm-year observations from 2,490 unique firms.

Developing and validating the measure of trade war uncertainty

We now describe the process of developing a firm-level, time-varying measure of managers' perceived trade war uncertainty (i.e., TWU). Leveraging the mandatory MD&A section of the annual reports during the period of 2007-2019, we utilize a machine learning approach called Word2Vec. This method starts with seed words that define each topic (e.g., trade war) and then automatically identifies synonyms for each seed words by learning the semantics (i.e., the meaning) of a word based on its context.

Our machine learning approach involves four steps. Appendixes A1-A2 in the Online Supplement[3] offer the full details. Here we provide an overview description. In the first step, we employ 12 seed words that define the trade war based on our reading of 200 randomly selected MD&A statements of annual reports, such as

[3] See Online Appendix at: https://github.com/YangXuuuu/AMCIS_Online_Appendix_New/blob/main/Online_Appendix.pdf

trade war, trade protectionism, unilateralism, and trade barrier. In the second step, we use the Word2Vec model to identify the top 30 synonyms for each seed word based upon its context. Afterwards, we manually inspect all the preliminary synonyms and eliminate words that are not applicable, by carefully studying its context in MD&A narratives. Such an approach efficiently identifies a broad set of words that describe the trade war and successfully creates an expanded and context-specific trade war-related dictionary (see Panel A of Online Appendix A2 for examples). Our final Trade War Dictionary consists of 51 keywords, which are listed in Panel B of Online Appendix A2.

In the third step, we develop an Uncertainty Dictionary in the same way. Following Kravet and Muslu (2013) and our reading of 200 randomly selected MD&A statements of annual reports, we first use 14 uncertainty- or risk- related seed words such as uncertainty, risk, and loss. Then we employ the Word2Vec model to obtain the top 30 synonyms for each seed word and manually eliminate words that do not fit. This leads to a final Uncertainty Dictionary of 288 keywords, as shown in Panel D of Online Appendix A2.

In the final step, we construct TWU by counting the number of occurrences of uncertainty-related keywords surrounding at least one trade war-related keyword in the same sentence, scaled by total number of sentences in the MD&A document:

$$\mathrm{TWU}_{i,t} = \frac{\sum_{w=1}^{D_{it}} \{1[w \in \mathbb{R}] \times 1[|w - p| \in \text{Same Sentencne}]\}}{S_{i,t}} \qquad (1)$$

where the subscripts i and t denote firm and year, respectively. $D_{i,t}$ ($S_{i,t}$) is the total number of words (sentences) in the MD&A document and $w = 0, 1, 2, \ldots, D_{i,t}$ are the words embedded in the MD&A. $1[\bullet]$ is the indicator function. $\mathbb{R}$ is the set of uncertainty-related keywords; p is the position of the closest trade war-related keywords (i.e., $p \in \text{Keywords}^{\text{trade war}}$). Therefore, terms in the numerator count the number of keywords associated with discussion of uncertainty-related and trade war-related topics that occur within the same sentence. Since our TWU measure is built on the firm-specific MD&A disclosures, it thus dynamically and accurately captures the intensity of trade war uncertainty perceived by top managers of individual firms. For expositional purposes, we multiply the measure by 100.

We then use various methods, including content validity, convergent validity, time-series patterns and industry variation, determinant model, and variance decomposition, to verify that our proposed TWU measure indeed captures the managerial perspective of trade war uncertainty. For more details, please refer to the Online Appendix A3.

Measuring strategic innovation management

We measure corporate strategic innovation management as the disproportionate quantity changes of invention and non-invention patents (i.e., utility patents and design patents). Because utility patents and design patents involve limited technological advancements and are more likely to be employed to indicate the quantitative change of innovation outputs, the quantity of non-invention patents can well capture a firm's opportunistic patenting activities. We use three measures of the quantity of patent applications (i.e., *PtAP*, *InvAP*, and *NonAP*) to measure firm innovation output.

Research Model

To examine the association between trade war uncertainty and firm opportunistic innovation strategy, we estimate the following baseline regression model:

$$Patent_{i,t} = \beta_0 + \beta_1 TWU_{i,t-1} + \sum Controls_{i,t} + Ind\ FE + \varepsilon_{i,t}. \qquad (2)$$

Where *i* indexes firm, and *t* indexes time. The dependent variable is one of the three innovation-output measures (*PtAP*, *InvAP*, and *NonAP*). Our independent variable is one-year lagged *TWU* to capture the causal effect, defined as firm-level trade war uncertainty in year *t-1*. We include a set of control variables that could affect a firm's innovation productivity. For more detailed definitions of variables, please refer to Appendix 1. We include industry fixed effects (i.e., one-digit CSRC industrial code) to capture unobserved industry-level time-invariant factors that are correlated with patenting activities. We do not include time fixed effect due to the inclusion of EPU which is a time series variable. Standard errors are clustered at the firm and year level to alleviate potential autocorrelation problems.

Empirical Results

Descriptive Statistics

Table 1 presents the descriptive statistics of the main variables for our baseline sample. We winsorize all continuous variables at the 1st and 99th percentiles. On average, a firm in our final sample files about 39 patents per year, almost 22 (i.e., 55%) of which are non-invention patents. Meanwhile, *TWU* has a mean value of 0.134 and a standard deviation of 0.370, suggesting significant variation across firms.

Variable	N	Mean	Std. Dev.	Q1	Median	Q3
PtAP	12,821	39.435	92.947	5.000	12.000	31.000
InvAP	12,821	17.352	43.619	2.000	5.000	13.000
NonAP	12,821	21.691	54.575	1.000	5.000	17.000
TWU	12,821	0.134	0.370	0.000	0.000	0.000
Sub/Cash	12,821	0.0377	0.163	0.000	0.001	0.010

Table 1. Summary Statistics

Baseline Analysis

The baseline regression results reported in Table 2 support our hypothesis 1. These results confirm our main hypothesis that firms are more likely to strategically exert efforts toward non-invention patenting activities rather than invention patent output when they perceive a high policy uncertainty unleashed through trade wars. In other words, firms pursue innovation by quantity instead of quality, which has no marginal effect on substantive innovation and creates a patent bubble.

	PtAP (t)	InvAP (t)	NonAP (t)
TWU (t-1)	0.124***	0.028	0.163***
	(5.04)	(1.20)	(5.43)
Cons, Control, Ind FE	YES	YES	YES
Observations	12,821	12,821	12,821
R2	0.205	0.222	0.148

Table 2. Trade war uncertainty and innovation output

The Moderation Effects

We further explore whether financial constraints affect the association between *TWU* and firm innovation opportunism. All variables are defined in Appendix 1. We find that financial constraints accelerate firm opportunistic innovation behavior to trade war uncertainty, which is coherent with our Hypothesis 2. The results in Column (2) of Table 3 show the moderating effect of managerial myopia (Hypothesis 3). The positive and significant estimated coefficient for the interaction term between *TWU(t-1)* and *Myopia(t-1)* supports to Hypothesis 3, which claims that an increase in managerial myopia will intensify the positive effect of TWU on firm strategic innovation management.

	NonAP (t)	NonAP (t)
TWU (t-1) * Constraint (t-1)	0.142**	
	(1.99)	
Constraint (t-1)	-0.119***	
	(-3.31)	
TWU (t-1) * Myopia (t-1)		0.144*

		(1.70)
Myopia (t-1)		-0.020
		(-0.65)
TWU (t-1)	0.102*	0.066
	(1.71)	(0.87)
Cons, Control, Ind FE	YES	YES
Observations	12,821	12,821
R2	0.153	0.153

Table 3. The Moderation Effects

Robustness Tests

This section provides a variety of robustness tests for our baseline findings and reports the results in the Online Appendix A4 due to space limitation. We first repeat our analysis by using *PtGR*, *InvGR*, and *NonGR* (See definitions in Appendix 1) as alternative innovation output measures following Bradley et al. (2017) and Chang et al. (2019) and then replace the basic innovation output measures with the proportion of the number of invention and non-invention patent applications over the total number of all types of patent applications, respectively. We also perform a difference-in-differences approach by relying on the 2018 U.S.-China trade war as a quasi-natural experiment to alleviate the potential endogeneity concern that omitted variables correlated with both TWU and innovation output might bias our findings. Overall, our inferences that companies opportunistically choose to generate more low-quality patents in response to trade war uncertainty do not change.

Additional Analyses

Innovation Strategy: To Maintain or to Terminate?

China's patent system requires firms to pay an incrementally increasing annual fee from the date of grant in order to maintain the legal effect of the patent. The expense of maintaining the "zombie" patent stock puts significant pressure on firm earnings performance. Thus, if firms really react to *TWU* by strategic patenting activities, they tend not to put the increased granted non-invention patents with low technical returns into industrial applications or intellectual property transactions. In this case, we predict that to deal with TWU strategically, firms will opt to apply for new non-invention patents and proactively terminate the legal effect of those that have been granted to relieve financial pressure.

To test this prediction, we use *NonTM* as our independent variable. The empirical results are presented in Column (1) of Table 4. These results confirm that firms strategically react to trade war uncertainty through manipulating non-invention patenting activities.

	NonTM (t)	Subsidy (t+1)	Subsidy (t+1)
TWU (t-1)	0.048**		
	(2.51)		
NonAP (t)		0.012***	0.017**
		(3.49)	(2.56)
Cons, Control, Ind FE	YES	YES	YES
Observations	12,821	10,676	4,766
R2	0.143	0.245	0.142

Table 4. Additional Analysis

Opening the Black Box of Firm Strategic Innovation Behavior

We continue our analysis by validating the ability of firm strategic innovation management to predict the future government supports received by listed companies. we estimate the following empirical model:

$$Subsidy_{i,t+1} = \beta_0 + \beta_1 NonAP_{i,t} + \sum Controls_{i,t} + Ind\ FE + \varepsilon_{i,t}. \qquad (3)$$

Column (2) of Table 4 reports the estimated results. Consistent with our prediction, firms that generate non-invention patents can obtain substantially more innovation supports by the government in the future.

Furthermore, we use a national-level pro-innovation campaign launched by Chinese central government in 2014 to fortify our inferences. This campaign might increase firms' opportunistic purposes because it aims at stimulating innovation through short-term government directives or policy incentives rather than long-term innovative ways. Hence, it would inevitably lead companies to plan to produce innovation output in a short time period and could aggravate firms' engagement in strategic patenting activities. To rule out this confounding effect, we re-estimate Eq. (3) but use only a pre-campaign period (i.e., ending with 2014). The result in Column (3) of Table 4 implies that the significant association between firm strategic innovation behavior and government subsidies is not driven by the national pro-innovation campaign.

Conclusion

Using the U.S.-China trade wars as an example of policy uncertainty, we find that firms experiencing higher TWU will generate more non-invention patents instead of high-quality invention patents, indicating that firms strategically react to TWU in their patenting activities by pursuing innovation quantity instead of quality. We further document that both financial constraints and myopic management strengthen the opportunistic incentives to innovate under trade war uncertainty. In addition, we open the behavioral black box of firms' strategic innovation and demonstrate that patents can be employed opportunistically to meet government policies to further attract more government subsidies. Since our study is in Chinese context, we acknowledge the limitations of our findings in generalizability. We will make further efforts to examine the strategic innovation management behavior in other contexts and detect the theoretical underpinning of our study in the future.

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Variable	Definitions
PtAP	Natural logarithm of one plus a firm's total number of patents filed in a fiscal year.
PtGR	Natural logarithm of one plus a firm's total number of patents filed in a fiscal year that are eventually granted.
InvAP	Natural logarithm of one plus a firm's total number of invention patents filed in a fiscal year.
InvGR	Natural logarithm of one plus a firm's total number of invention patents filed in a fiscal year that are eventually granted.
NonAP	Natural logarithm of one plus a firm's total number of non-invention patents (i.e., utility patents and design patents) filed in a fiscal year.
NonGR	Natural logarithm of one plus a firm's total number of non-invention patents (i.e., utility patents and design patents) filed in a fiscal year that are eventually granted.
NonTM	Natural logarithm of one plus a firm's total number of non-invention patents (i.e., utility patents and design patents) filed in a fiscal year that are eventually terminated.
TWU	Measure of firm-level trade war uncertainty, measured as the percentage of the number of trade war risk sentences on total number of sentences in the MD&A section of annual reports.
ROA	Return on assets defined as net income before extraordinary items scaled by total assets.
Size	Natural logarithm of total assets.
Lev	Total liabilities divided by total assets.
Growth	The change in year-to-year total sales over last year's value.
Age	Natural logarithm of 1 plus the number of years since a firm has been publicly listed.
RDI	The percentage of total R&D expenses on total sales. Missing R&D values are set to zero.
PPE	Net value of property, plant, and equipment scaled by total assets.
BM	Book-to-market ratio measured as book value divided by market capitalization.
Capital	Capital expenditures divided by total assets.
IO	The proportion of firm shares owned by institutional investors.
EPU	Measure of economic policy uncertainty based on newspapers in Hong Kong of China developed by Baker et al. (2016). We calculate the annual EPU as the average of monthly indexes within a year and divide it by 103.
Subsidy	The percentage of the amount of government innovation subsidy received by the firm scaled by total assets. Missing values are set to zero.
Sub/Cash	The subsidy received by the firm scaled by cash holdings. Missing values are set to zero.
Constraint	An indicator variable equal to one if a firm's WW index is above the sample median and zero otherwise. WW index is measured as -0.091 * (operating income plus depreciation)/total assets - 0.062 * dividend dummy (a variable indicating positive preferred or common dividends) + 0.021 * (book value of long-term debt)/total assets – 0.044 * natural logarithm of total assets + 0.102 * (annual percentage change in industry sales) – 0.035 * annual percentage change.
Myopia	A dummy variable equal to one for firms above the sample median value of ShInv and zero otherwise. ShInv is measured by a firm's short-term investments (i.e., transactional financial assets + net available-for-sale financial assets + net held-to-maturity investment) divided by total assets at the beginning of the fiscal year.

Appendix 1. Variable Definitions