Research Article

Identifying the Dynamic Influence of Economic Policy Uncertainty on Enterprise Investment Using Functional Data Analysis

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Received 4 November 2021; Revised 28 January 2022; Accepted 16 February 2022; Published 17 March 2022

Academic Editor: Aditya Rio Prabowo

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Economic policy uncertainty (EPU) is one of the important influencing factors for enterprise investment. By its nature, enterprise investment is dynamically affected by uncertainty. We examine the time-varying impact of EPU on the level of corporate investment by introducing functional data analysis (FDA). Based on smoothing the discrete data of 106 China Securities Index (CSI) 300 firms into the continuous curve, we examine the dynamic relationship between EPU on corporate investment level and investment efficiency. In addition, we explore the effect of EPU on the level of corporate investment and investment efficiency after grouping regressions in a functional model. The findings show the following: Firstly, there is a suppressive effect of rising EPU on the level of corporate investment. However, when the EPU is low, it has a significant promoting effect on the level of corporate investment and gradually decreases with the increase of uncertainty level. Secondly, elevated EPU has a promoting effect on the efficiency of corporate investment. The inhibitory effect on firm investment efficiency is observed at low EPU and changes to a promotional effect at high EPU. Thirdly, increasing EPU has a greater inhibitory role in the investment level of nonstate firms and a greater promotional role in the investment efficiency of state firms. We seek to expand the research on the impact of macrouncertainty on microfirm investment and introduce FDA to provide a meaningful reference to solve the current controversial issue.

1. Introduction

As macroeconomic policies are intimately related to the enterprises’ survival and development, enterprises have to take into account the impact of the external economic environment on their development when they continuously use investment activities to adjust their capital structure. Among the various influencing factors of enterprise investment, economic policy uncertainty (EPU) is an element that cannot be ignored in our exploration of the influences on enterprise investment, as the timing and direction of economic policy adjustments can bring a certain degree of uncertainty to economic agents, which in turn affects the investment decisions of enterprises. In the existing literature, the research on how EPU contributes to the level of corporate investment and investment efficiency is broadly divided into two schools of thought. A perspective suggests that the point at which EPU rises is a good investment opportunity for firms to seize [1, 2]. The other perspective is that EPU represents risk, and firms are less willing to invest out of prudence [3]. This discrepancy in studies’ findings may be caused by firm heterogeneity and differences in research methods. The firm-level measures of economic policy uncertainty by most scholars include variability in expected growth rates of demand [4, 5], individual firm share price volatility changes [6], and implications of changes in top company or country leadership [7, 8]. In accordance with the economic policy uncertainty index constructed by Baker et al. [9], the existing literature investigates the impact of economic policy uncertainty on different firms’ investment decisions of using GMM models [10], constructing time-varying parametric VAR models [11], and so on.
In most of the current studies, scholars have focused on the impact of macrouncertainty on microfirm investment by taking the perspective of discrete data. For example, Rao et al. have studied the impact of economic policy uncertainty on firms’ investment behavior using quarterly data [12], while Luo [13] and Xu et al. [14] employed quarterly data to explore the relationship between EPU and firms’ investment structure. The available literature is generally conducted by traditional panel regression models or threshold regression models; however, the measurement methods are constrained with more constraints in terms of discrete data, and the obtained empirical results can only express part of our information. To begin with, panel regression models demand that the sampling frequency of sample variables has to be the same, where data should not be missing and have restrictions in selecting data. Then, conventional discrete methods can only portray the average impact between EPU and corporate investment, whereas relations among them ought to be time-varying; that is, the relationships at different temporal sites are supposed to satisfy explicitly. Functional data analysis (FDA), brought forward by Ramsay and Dalzell, intrinsically takes the observed data as a functional integral via infinite-dimensional space analysis and unveils the findings by geometric images, which inherently surpasses the frequency constraint of samples for articulating the unsighted data information [15]. FDA has been widely used in data processing aspects of analysis related to various industries. Yu and Lu constructed the collected discrete data into functional data to study the structure and development of the online group buying market [16]. By transforming discrete data into functional data for data preprocessing, Zhou et al. estimated the intensity of stock capital flows using principal component analysis of functional data, which was more accurate in grasping the meaning of indicators, faster in the calculation, and more effective in estimating the results [17]. Besides, functional regression analysis in the FDA also plays a role in examining quantitative relationships between variables. Wang and Ding used the functional nonparametric regression model to the Shanghai Stock Exchange index data to illustrate the advantage of functional models having greater flexibility and applicability [18]. Cheng and Yan analyzed the dynamics of the consumption function in China with the help of functional regression models [19]. FDA not only has a promising application in finance but also is widely used in other professional fields to process data and improve the underlying models to facilitate more accurate results for empirical analysis [20–22]. Therefore, we apply the FDA approach to characterize the time-varying effects of economic policy uncertainty on firms’ investment behavior by constructing a functional regression model, which provides a novel way of thinking to study the time-varying relationship between economic policy uncertainty and firms’ investment [23].

With the above analysis, we construct a functional linear regression model to probe the time-varying effects of EPU on the investment level and efficiency of enterprises by using China Securities Index (CSI) 300 enterprises (106 enterprises in total) as the research sample. In previous studies, the static relationship between EPU and business investment was mostly portrayed using discrete panel data, which led to the conclusion that EPU promotes or discourages business investment from a single perspective [24–26]. In reality, however, EPU is a time-varying macrovariable, and its impact on business investment varies somewhat depending on the time period. We look at the dynamic relationship between EPU and business investment from a continuous perspective to quantitatively examine the time-varying effects of EPU on business investment in existing studies, helping to resolve some of the controversial findings. Furthermore, according to the nature of equity, we sort the sample enterprises into state-owned enterprises (SOEs) and nonstate-owned enterprises (non-SOEs) and then contrast and analyze the time-varying heterogeneous effects of EPU on the investment level and efficiency of enterprises after grouping regression. Traditional discrete models can only determine the presence or absence of heterogeneous effects from observing significance and judging positive or negative results [27–29]. We introduce a functional regression model that allows us to visually observe not only the time-varying impact of EPU on SOE investment and non-SOE investment across time but also to what extent EPU has an impact on SOEs and non-SOEs, respectively. In addition, we also conducted correlation tests on the control variables, all of which have time-varying characteristics, laying the foundation for further research on the dynamic moderating role between EPU and enterprise investment. With the dynamic nature of the ties between EPU and corporate investment, we contribute the following to the existing studies in order to quantify this time-varying relationship: (1) To analyze the interaction of EPU on the level of corporate investment and investment efficiency, we interpret the relationship between EPU and corporate investment from the dynamic perspective of discrete data continuity, which transcends the statistical research approach of traditional econometric models and makes it possible to depict the time-varying relationship between EPU and corporate investment from a successive perspective. (2) As the unique economic system in China is a state-owned enterprise-oriented economic model, it is helpful to divide the sample into state-owned and nonstate-owned enterprises by the nature of their equity so as to look into the differential impact of EPU on those enterprises with different nature of equity separately for government to “take appropriate steps.” (3) From the dynamic significance tests on the control variables, we obtain profiles of continuous parameters that provide insights for further analysis of the time-varying effects of different control variables on the relationship between EPU and corporate investment in the future.

The remaining parts of the paper have the following structure. Section 2 outlines some theoretical background of how EPU works on corporate investment, together with the research hypothesis. Section 3 illustrates data sources and functional regression methods applied in the paper. Section 4 supplies the results of model construction and empirical analysis. Section 5 contains discussions of the empirical results. Section 6 wraps up the paper.
2. Theoretical Analysis and Hypothesis

It has been focused on how the uncertainty brought by economic policies would impact firms’ investment behavior, and a wide range of empirical studies have been conducted by some scholars from different perspectives. Real options theory states that investment opportunities can be viewed as an option held by firms, whereas rising uncertainty may raise the marginal investment cost by boosting the value of the option, thereby reducing investment. The presence of uncertainty makes it difficult for firms to predict the future course of an investment project, and therefore, firms can gain more information by waiting before making an investment decision; that is, the value of the option increases. Sensible investors rationally allocate their investment structure, while higher EPU increases the value of the “wait” information, thus maximizing the return on the investment project.

2.1. Implication of Economic Policy Uncertainty on the Level of Enterprise Investment. Real options theory is an important theory for studying corporate investment decisions under uncertainty. McDonald and Siegel first established a real option pricing model in corporate investment [30], and then Dixit and Pindyck studied and discussed real options theory systematically [31]. Simply put, real options theory assumes that the investment is unrecoverable and can be compared to a call option for corporate investment opportunities. When a business invests, real options theory is understood in different ways depending on the purpose of the project. If a particular enterprise pays a certain fee to purchase an asset whose price will change in the future, we consider the fee that the enterprise regulates as an option fee; if the enterprise has already made an investment decision in the past, the investment made at this stage can be considered as exercising the exercise of the option that has been originally purchased.

Uncertainties have important implications for economic performance. Hartman discussed the effect of uncertainty on investment under a set of conditions such as assuming that firms are risk-neutral and perfectly competitive, concluding that uncertainty can lead to increased investment in firms [32]. Pindyck and Abel used the assumption of a stochastic process different from Hartman’s but instead assumed that the random variables obey the Wiener process to build the model so that they solved the drawback that all present and future in the model are uncertain [33, 34]. Notwithstanding, their conclusions are drawn under risk-neutral conditions, while Nickell found that if firms are risk-averse, their investment efficiency will be reduced under uncertainty [35]. Conservative investors believe that the uncertainty associated with adjusting economic policies discourages business investment because rising policy uncertainty increases expected costs and thus reduces long-term investment [36, 37]. Campello et al. and Gulen and Ion demonstrated that companies alter their capital plans and prefer to decrease their expenditures in periods of the financial crisis and high economic policy uncertainty of using questionnaires and traditional regression analysis [38, 39].

For developing countries with relatively weak economies, corporate management is exposed to uncertainty about changes in the external environment when governments change economic policies, which makes them more cautious in formulating long-term investment strategies. EPU also has a more drastic impact on countries in transition than countries with strong economies. Since macro-policies represent the future direction of economic development, companies mostly compete according to the policy orientation in the process of economic policy change from industrial policy-oriented to competition policy-based [12, 40]. It is important to note that the above studies are all based on discrete data examining the average impact of EPU on the level of business investment, and there is no literature yet examining the dynamic relationship between the two. In this context, we expect to introduce the FDA to focus on the time-varying impact of EPU on the level of business investment. Based on this, we propose the following hypothesis to test the view:

H1: rising economic policy uncertainty has a dampening effect on the level of enterprise investment.

2.2. Implication of Economic Policy Uncertainty on the Efficiency of Corporate Investment. There are two broad approaches to measuring the efficiency of corporate investment; the first is based on Mark et al.’s model of corporate investment, which is improved to classify firms as overinvested and underinvested through the regression residuals of the model and used as an indicator of investment efficiency [41]. Then, there is Wurgler mainly, which uses the coefficient of investment response to investment opportunities as an indicator of firm investment efficiency [42], and this method has been widely used in measuring investment efficiency indicators [43, 44].

Theoretically, in a perfect market economy, a firm’s investment should be sensitive only to economic factors in the market. The financing constraint theory states that if a firm is strongly influenced by financing constraints, the firm’s investment will be more dependent on the firm’s internal cash flow. In terms of product markets, a highly competitive product market will alleviate the firm’s internal agency problem and reduce the financing constraint, thus improving the efficiency of the firm’s investment [45]. In terms of factor markets, financial and credit markets have significant effects on the efficiency of firm investment. Financial market frictions increase firms’ capital adjustment costs and thus reduce their investment efficiency [46, 47]. From the credit market perspective, one of the important financing channels for Chinese firms is bank credit financing [48, 49], and an enhanced EPU will lead to a lower amount of bank credit financing and more difficult financing. Based on the financing constraint theory, an increase in EPU hinders firms from making optimal investment decisions and thus affects their investment efficiency.

Bai et al. and Sun et al. showed that investment efficiency is outperformed in China compared to countries such as the US, with a high return on invested capital potentially moderating the risk associated with uncertainty [50, 51].
Using election data across countries, Durnev considered that the sensitivity of corporate investment to stock prices decreases in election years, which he attributed to the fact that stock prices reflect political uncertainty in election years, leading to a reduction in the information content of stock prices [52]. Pastor and Bonnaire supposed that higher EPU incites mismanaged corporate management, who perceived that this uncertainty allows them to engage in “empire building” and pursue private profits without direct consequences, excusing the negative impact of uncertainty due to poor governance, which results in inefficient investment [53, 54]. Overall, therefore, the impact of EPU on the efficiency of corporate investment is reflected in the fact that when uncertainty is elevated because of the lack of clear policy expectations, the firm-level investment will be more economically driven. This is manifested as an increase in investment efficiency. However, no scholar has yet explored the specific impact over a certain period of time, so we propose a second hypothesis to test the time-varying impact of EPU on firms' investment efficiency:

H2: rising economic policy uncertainty has a boosting effect on enterprise investment efficiency.

2.3. Economic Policy Uncertainty Has a Different Impact on Corporate Investment of Different Nature

State-owned enterprises controlled by the government have certain resource advantages and information orientation, which give them a natural advantage in making investment decisions as well as making it relatively easy to borrow from state-owned banks. In contrast, non-SOEs are weaker in this regard. Yet, non-SOEs have a strong profit motive, while the weakness in terms of government agency thus motivates them to pursue more profit maximization in their choice of investment strategy. When firms face relatively low business risks, the uncertainty of their expected cash flows decreases, which not only alleviates the financing constraints faced by firms but also has a positive impact on boosting entrepreneurial confidence, prompting firms to expand their investments and thus weakening problems such as underinvestment [55]. However, it is worth noting that the decline in business risks of firms under the accommodative monetary policy may also lead to management's overconfidence. Excessive management confidence will increase firms' risk tolerance and make management more aggressive in investment decisions, and the overinvestment problem may become more serious [56]. Chen et al. argued that SOEs are more aware of government intentions in their business activities, and most of SOEs' investment and financing decisions are made under government directives; hence, the disincentive effect of EPU on SOEs is narrower in comparison to non-SOEs [57].

Taking developing countries as an example, in times of economic crisis, the government will take certain intervention measures to regulate the macroeconomy, which will have a differential impact on firms with different property rights nature. Foremost, the management of SOEs is less regulated by the controlling shareholders due to their special relationship with the government and is more aggressive in their investment strategies [58, 59]. SOEs supported by the government are more willing to make investment decisions in accordance with policy changes, having greater influence from economic policies [60, 61]. Moreover, the credit transmission channel is the main transmission channel of monetary policy, and the credit funds are mostly injected into SOEs in the form of bank loans, resulting in SOEs being more prone to follow economic policy changes [62, 63]. Raúl et al. argued that this effect is more pronounced for banks with larger enterprises, liquidity shortages, and poor liquidity [64]. Khanh et al. revealed that the positive impact of economic policy uncertainty on firm diversification is only manifested in large and medium-sized firms and that higher uncertainty has a greater impact on SOE diversification [65]. In terms of the relative importance of non-SOEs, they tend to scale down their investments when uncertainty is high, which leads them to prefer economic policy stability to economic policy changes. As investors in non-SOEs are more cautious in making investments, the higher uncertainty causes firms to reduce their investment levels [66]. At this point, SOEs focus more on improving the efficiency of their corporate investments when EPU is higher. As a result, we propose that economic policy uncertainty has a heterogeneous impact on the investment behavior of different firms and that the heterogeneous impact has different effects over time. Based on this, we thus propose the following hypothesis to test the view:

H3: economic policy uncertainty has a greater dampening effect on the level of investment in nonstate-owned enterprises.

H4: economic policy uncertainty promotes greater investment efficiency in state-owned enterprises.

Based on the above analysis, we present a summary of the literature in Table 1, which includes literature for and against our proposed hypothesis.

By summarizing the above literature, it can be found that relevant studies at home and abroad have accumulated relatively fruitful results and deepened the understanding of the relationship between EPU and corporate investment. However, from the existing literature, most of the scholars' studies have dealt with the facilitating or inhibiting relationship between the two, but few have considered the key factor that their impact relationship may be time-varying. Indeed, EPU is subject to macroeconomic fluctuations that bring uncertainty that is not static. The introduction of corresponding national policies also has an important impact on the functioning of the economy. Therefore, we attempt to use the FDA to quantify the time-varying relationship between EPU and business investment in order to provide reference and input to the government in maintaining economic stability and formulating economic policies.

3. Data and Methodology

3.1. Data Sources and Sample Selection. We adopt the China Economic Policy Uncertainty Index developed and compiled by Baker, Bloom, and Davis (BBD) to estimate the impact of economic policy uncertainty on corporate
investment [9]. All other financial data in our paper are obtained from the Wind database classification of CSI 300 companies, where financial companies, ST/ST∗ companies, and companies with missing values of financial data are excluded from the processing. The final observations were 6,890 annual and 5,512 quarterly data for 106 companies and 52 macrovariables (EPU) quarterly data, and the sample was selected from various industries with certain representativeness. Of these, 56 were state-owned enterprises, and 50 were nonstate-owned enterprises. As SOEs have diversified industries, their strong economic power allows them to take risks in exchange for returns when faced with uncertainty shocks. Nonstate-owned enterprises, on the other hand, are more exposed to economic fluctuations due to their lower market status and inadequate relevant legal systems, and business organizers are more likely to expect risk aversion. Therefore, state-owned enterprises are defined as risk-taking enterprises and nonstate-owned enterprises as risk-averse enterprises [67, 68].

3.2. Variable Definition and Measurement. Drawing on Li and Xiao, we use capital expenditures (INVEST) to measure the level of investment by firms and divide by total assets for dimensionless treatment as the explanatory variable in the regression model [69].

The EPU Index, developed by Stanford University and the University of Chicago’s BBD in 2013, is widely used to measure economic policy uncertainty [70]. The index is constructed by modeling articles that appear in newspapers over the years with keywords, including “policy,” “tax,” “finance,” “economy,” “budget,” “cost,” and “money,” then, according to certain criteria, the statistical data are quantified, and finally, the monthly indicators of EPU are derived. In order to facilitate the subsequent empirical analysis, we use the EPU values of March, June, September, and December as quarterly variables and take logarithmic treatment as the explanatory variables of the regression model [2, 51].

EPU, as a macrofactor affecting business investment, is not the only factor affecting business investment. In order to eliminate the influence of possible confounding factors, we selected five microcontrol variables that have an impact on business investment concerning existing studies. These variables have been widely used in existing studies and have been proven to have a definite impact on business investment: (1) Tobin Q (TQ), measured by the sum of the market value of equity and market value of liabilities divided by total assets [10, 12]. It represents the fact that firms face reduced investment opportunities under conditions of elevated uncertainty. (2) Return on assets (ROA), measured by net profit after tax adjusted by total assets. It is used to indicate the impact of uncertainty on a firm, resulting in a reduction in its profitability [52, 71]. (3) Operating cash flow (CF). It is expressed by the cash flow generated by all transactions and events of the enterprise other than investing and financing activities and is used to control for the ability of enterprises with large cash flows to withstand risks [14, 72]. We chose to divide the data by total assets for dimensionless processing. (4) Enterprise size (SIZE). It is determined by the total assets of the enterprise and is treated as logarithmic in the text in order to facilitate calculation with the rest of the variables, to eliminate differences due to different value domains, and to achieve smooth data without changing the nature and correlation of the data. It is used to control for the weakened ability of large enterprises to invest when uncertainty is high [73, 74]. (5) Financial leverage (LEV). It is measured by the ratio of total assets to equity capital and is used to evaluate the increased risk of corporate liabilities in the face of uncertainty shocks [75]. In order to ensure the reliability of the results, we have standardized the data for all companies, being different variables with the same scale. Detailed variable definitions, calculation methods, and reference sources are shown in Table 2.

3.3. Methodology

3.3.1. Data Preprocessing. The key to functional data analysis preprocessing is how to transform discrete data into functional data over the entire interval, which is also known as discrete data functional. If we can ensure that the selected discrete data are error-free, functional can be achieved by simple interpolation. However, the actual data cannot be error-free, and these errors need to be filtered by smoothing techniques to achieve functional data. Specifically,
smoothing methods are used to convert discrete data into smooth function-based data with continuous values by using the function information of nearby points when estimating the function values of the interval.

Basis function fitting is the most commonly used method in data smoothing, where the most critical step is to select a suitable basis function. The common basis functions are Fourier basis, B-sample basis, polynomial basis, and so on. Different basis functions are suitable for fitting different data types. Fourier basis is more suitable for fitting data with periodicity, while B-sample basis is suitable for fitting data without obvious periodicity. The data type we selected is not significantly periodic, so in the following, we use the B-sample basis function to smooth the data, and the coefficient vectors are estimated using least squares. Assuming that $k$ known basis functions $\{\phi_k(t)\}, k = 1, 2, \ldots, K$, are used to estimate the function, $T$ is the time domain, and the estimated fitted function is shown in

$$f_i(t) = \sum_{k=1}^{K} \xi_{ik} \phi_k(t) t \in T. \quad (1)$$

And the derivative of the fitted function $f_i(t)$ can be expressed as

$$D^m(f_i(t)) = \sum_{k=1}^{K} \xi_{ik} D^m(\phi_k(t)). \quad (2)$$

In (2), $D^m$ is denoted as the $m$th order derivative of the function. $\xi_{ik}$ is the coefficient determined by minimizing the penalized sum of squared residuals (PENSSE), as shown in

$$\text{PENSSE}_m(\lambda) = \sum_{j=1}^{T} \left[ f_{ij} - \sum_{k=1}^{K} \xi_{ik} \phi_k(t_j) \right]^2 + \lambda \int_T [D^m(f_i(t))]^2 dt. \quad (3)$$

In (3), $f_{ij}$ is used to fit the measurement of the function $f_i(t)$, and $t_j$ is the appropriate measurement time. For example, $\int_T [D^2f_i(t)]^2 dt$ is the integral of the squared second-order derivative of $f_i(t)$ for $m = 2$ and is more sensitive to the curvature of the function $f_i(t)$. See Ramsay and Silverman for details [23].

### 3.3.2. Selecting Data Smoothing Parameters

In the rough penalty method, the selection of the smoothing parameter $\lambda$ is of particular importance, and the generalized cross-validation (GCV) proposed by Craven and Wahba contributes to finding the optimal value of $\lambda$ [76]. The best smoothing parameter is derived from the minimum value of GCV($\lambda$), as shown in

$$\text{GCV}(\lambda) = \frac{n}{n - df(\lambda)} \frac{\text{SSE}(\lambda)}{n - df(\lambda)} \quad (4)$$

In (4), $n$ represents the number of samples, $df(\lambda)$ denotes the degrees of freedom, and $\text{SSE} = \sum (y_i - y_i(\lambda))^2$ represents the fitted sum of squares of the total residuals. Taking the B-sample basis function of 106 enterprises as an example, Figure 1 shows the GCV variation curve of $\log_{10}(\lambda)$. It can be seen that the minimum value of GCV occurs at $\log_{10}(\lambda) = 0.25$. The parameter $\lambda$ is a smoothing parameter, which is used to measure the degree of fit. When $\lambda$ is closer to 0, it means that the fit curve is closer to the interpolated value of the data, and the degree of fit is better. So it is proved that the data fit is good. The smoothing parameters for the remaining variables are shown in Table 3.

### 3.3.3. Functional Regression Analysis

In contrast to previous traditional static regression analysis, we use the functional regression approach for dynamically quantifying the time-varying relationship between EPU and firm investment. Aiming at estimating the time-varying functional relationship, it is possible for the impact of the $j$th explanatory factor $X_j(t)$ on firm investment $y(t)$ at each time point to be measured continuously by the parametric curve $\beta_j(t)$, which provides a detailed analysis of such impact. By setting $Y(t) = (y_1(t), y_2(t), \ldots, y_N(t))$ as a function vector of $N \times 1$, where $N$ is the number of firms, and defining $X(t) = (1, x_1(t), \ldots, x_k(t))$ as a design matrix of $N \times (k + 1)$, $Y(t) = X(t)\beta(t)$ is made to hold by finding $k + 1$ parameter curves $\beta(t) = (\beta_0(t), \beta_1(t), \ldots, \beta_k(t))$. Similar to the ordinary least-squares method, the objective of the function regression is to minimize the sum of squares of the errors, as shown in

$$\text{ISSE}[\beta(t)] = \int ||Y(t) - X(t)\beta(t)||^2 dt. \quad (5)$$

Here, $||$ denotes the Euclidean parameterization, and through (5), we can obtain $\beta(t)$ that minimizes. Accordingly, we can use time-series data in a functional regression model; that is, the functional regression model is introduced to study the impact of economic policy uncertainty on corporate investment with some statistical significance.

### Table 2: Variables definitions.

| Variables         | Names              | Symbols | Frequency | Description                                                                 | References |
|-------------------|--------------------|---------|-----------|-----------------------------------------------------------------------------|------------|
| Dependent variable | Enterprise investment | INVEST | Yearly    | Capital expenditure/total assets                                           | [48]       |
| Independent variable | Economic policy uncertainty | EPU   | Quarterly | China’s economic policy uncertainty index taken as logarithm                | [2, 51]    |
|                    | Tobin Q            | TQ      | Quarterly | Market value of equity and liabilities/total assets                         | [10, 12]   |
|                    | Return on assets   | ROA     | Yearly    | Ratio of net profits to total assets                                        | [52, 71]   |
| Control variables  | Operating cash flow | CF      | Yearly    | Operational cash flow/total assets                                         | [14, 72]   |
|                    | Enterprise size    | SIZE    | Yearly    | Total enterprise assets are taken as logarithm                              | [73, 74]   |
|                    | Financial leverage | LEV     | Yearly    | Corporate gearing ratio                                                     | [75]       |
4. Model Specification and Empirical Results

4.1. Model Specification. For testing hypothesis H1, referring to the study of Gulen and Ion, we take INVEST as the response variable, EPU as the independent variable, and the rest of the variables in Table 1 as control variables, constructing the following functional model as [39]

\[
\text{INVEST}_i(t) = \beta_0(t) + \beta_1(t)\text{EPU}_i(t) + \beta_2(t)\text{TQ}_i(t) + \beta_3(t)\text{ROA}_i(t) + \beta_4(t)\text{CF}_i(t) + \beta_5(t)\text{SIZE}_i(t) + \beta_6(t)\text{LEV}_i(t) + \epsilon_i(t). \tag{6}
\]

In (6), \(i\) is the number of firms, \(\beta_k(t)\) is the intercept term, \(\beta_k(t)\) \((k = 1, \ldots, 6)\) is the correlation coefficient function of the control variables, and \(\epsilon_i(t)\) is the random perturbation term. To test the significance of the control variables, we use (6) to examine the five control variables in Table 1 with the variable EPU taken out, and the results are shown in Figure 2.

In Figure 2, the horizontal axes all represent sample intervals. In Figure 2(a), \(\beta_2(t)\) represents the curve of the effect of TQ on INVEST. In Figure 2(b), \(\beta_3(t)\) represents the curve of the effect of ROA on INVEST. In Figure 2(c), \(\beta_4(t)\) represents the curve of the effect of CF on INVEST. In Figure 2(d), \(\beta_5(t)\) represents the curve of the effect of SIZE on INVEST. In Figure 2(e), \(\beta_6(t)\) represents the curve of the effect of LEV on INVEST. As it can be seen from Figure 2, curves \(\beta_2(t)\), \(\beta_3(t)\), and \(\beta_6(t)\) all fluctuate gradually downward from positive to negative, indicating that when EPU is low, there are more investment opportunities for enterprises, with relatively large enterprise size and low enterprise debt risk. The curve \(\beta_3(t)\) exhibits a significant negative effect overall, while the curve \(\beta_4(t)\) displays a significant positive effect, which implies that the profitability of enterprises is significantly negative and the risk resistance of enterprise investment is significantly positive in the observed interval.

Intending to study the hypothesis, we adopt the sensitivity of investment to investment opportunities to measure the efficiency of firms’ investment [29, 34]. In traditional theoretical analysis, corporate investment should be highly correlated with the investment opportunities it faces, so that efficient investment is manifested by a high sensitivity of investment to investment opportunities; conversely, we consider it as an inefficient investment behavior if the investment will have a low sensitivity to investment opportunities. Accordingly, we establish the regression model as in
\[ \text{INVEST}_i(t) = \beta_0(t) + \beta_1(t)\text{EPU}_i(t) + \beta_2(t)\text{TQ}_i(t) + \beta_3(t)\text{TQ}_i(t) \times \text{EPU}_i(t) + \beta_4(t)\text{ROA}_i(t) + \beta_5(t)\text{CF}_i(t) + \beta_6(t)\text{SIZE}_i(t) + \beta_7(t)\text{LEV}_i(t) + \epsilon_i(t). \]

The variables in (7) are identical to those in (6), but the difference lies in the inclusion of the interaction term of TQ and EPU. By our hypothesis, we anticipate that the interaction term coefficient \( \beta_3(t) \) is dramatically positive, illustrating that when economic policy uncertainty is high, firm investment is more sensitive to investment opportunities, and firm investment efficiency is higher consequently.

4.2. Empirical Results

4.2.1. Descriptive Statistics. The descriptive statistics of our main variables are reported in Table 4. It is shown that the mean value of investment level (INVEST) is 0.054, while the standard deviation reaches 0.051, illustrating that the level of corporate investment varies significantly between individuals and among economic cycles. EPU takes a logarithmic treatment, with a large difference between the maximum and minimum values, demonstrating the large fluctuation of economic policy uncertainty during the sample period. All of the quantitative characteristics of the remaining indicators have different degrees of variation, which evidences the representativeness of the enterprises in our selected sample.

4.2.2. The Impact of EPU on Enterprise Investment Levels. We calculate the optimal smoothing parameter \( \lambda \) based on equation (4), and the results are shown in Figure 1. The coefficient curve is shown in Figure 3, with the dashed line indicating the 95% confidence interval. Figure 3(a) shows the EPU change curve, which clearly shows that the EPU tends to climb over the sample interval and shows a significant increase after 2015. Figure 3(b) shows the curve of the impact of EPU on the level of business investment, including the 95% confidence interval. The curve \( \beta_{21}(t) \) is significantly positive until 2015. When EPU rises significantly, the curve \( \beta_{21}(t) \) gradually extends downwards, and the negative effect increases. In summary, the coefficient curve \( \beta_{21}(t) \) shifts from positive to negative throughout the observation period, indicating that an increase in EPU leads to a decrease in the level of business investment. Therefore, the results support hypothesis H1.

4.2.3. The Impact of EPU on Corporate Investment Efficiency. For testing hypothesis H2 and ascertaining the relationship between EPU and enterprise investment efficiency, we performed a functional regression analysis on (7). By observing the change curve of \( \beta_{31}(t) \), we analyze the effect of EPU on the investment efficiency of enterprises, and the results are shown in Figure 4. We discover that \( \beta_{31}(t) \) shows an asymmetric “V” curve, and the overall effect shifted from a significant negative effect to a significant positive effect at the 5% significance level, testing hypothesis 2. It is observed that when EPU rises significantly, investment efficiency also rises substantially. It indicates that the sensitivity of firm investment to investment opportunities decreases as EPU
rises; that is, firm investment efficiency will increase when EPU rises.

4.2.4. The Impact of Property Rights Heterogeneity on the EPU Effect. The impact of uncertainty on the economic situation is mainly manifested in the uncertainty of political cost, where the government hopes to achieve optimal political cost by adjusting economic policies to achieve the purpose of promoting enterprise investment [77]. But in fact, the rise in EPU will increase the uncertainty of future cash flows, thus discouraging business investment. Furthermore, due to insufficient information disclosure and the existence of time lag, state-owned enterprises rely on government protection and bailout and can better avoid risks and reduce losses and increase investment amount and investment efficiency in the case of macroeconomic fluctuations, but nonstate-owned enterprises tend to be conservative in formulating investment strategies to prevent economic development from shocks owing to their economic weakness and inadequate ability to resist risks, while investment level decreases and investment efficiency also decreases [78].

In addition, we classified the sample enterprises into two categories of state-owned enterprises and nonstate-owned enterprises according to the different nature of property rights and separately regressed (6) and (7) in groups while observing the curve changes; the results are shown in Figures 5 and 6. While we found that the effect of EPU on the level of investment by state-owned enterprises is largely facilitative, the effect on nonstate-owned enterprises shifts from facilitative to suppressive as EPU rises, and then the suppressive effect, although diminishing, still shows a suppressive effect. This is the reason why we observed that the negative effect of rising EPU on the investment level of non-SOEs changes more sharply, while the positive effect on the investment level of SOEs is more pronounced. This also suggests that risk-averse firms exhibit a boost in firm investment in the face of elevated EPU. Risk-averse firms, on the other hand, have a significant inhibitory effect on firm investment in the face of elevated EPU [79]. Overall, the influence of EPU on the investment level of enterprises is more pronounced and more strongly inhibited in the group of non-SOEs. This result verifies hypothesis H3.

As we can see from Figure 6, it is observed that EPU shows a negative to positive trend on the investment efficiency of state-owned enterprises, while it shows a significant negative impact on nonstate-owned enterprises in stages. Collectively, findings in Figure 6 indicate that the effect of rising EPU on firms’ investment efficiency is less inhibitory and more facilitative in SOEs and more inhibitory in non-SOEs. The analysis of the above results proves H4. This suggests that risk-taking firms exhibit a promotion of corporate investment efficiency in the face of elevated EPU. In contrast, risk-averse firms have a significant inhibitory effect on firm investment efficiency when faced with a higher EPU [80]. This may be attributable to the fact that managers of non-SOEs generally adjust their investment strategies to

| Variables | Observations | Mean       | Minimum value | Maximum value | Median    | Standard deviation |
|-----------|--------------|------------|---------------|---------------|-----------|-------------------|
| INVEST    | 1378         | 0.054      | −0.095        | 0.298         | 0.342     | 0.051             |
| EPU       | 52           | 5.210      | 4.148         | 6.748         | 5.108     | 0.618             |
| ROA       | 1378         | 5.938      | −25.245       | 38.604        | 4.706     | 5.780             |
| CF        | 1378         | 0.074      | −0.346        | 0.396         | 0.071     | 0.078             |
| SIZE      | 1378         | 23.837     | 19.510        | 28.193        | 23.828    | 1.684             |
| LEV       | 1378         | 51.832     | 3.410         | 117.302       | 52.756    | 19.536            |
| TQ        | 5512         | 2.106      | 0.549         | 23.362        | 1.510     | 1.723             |

**Table 4: Descriptive statistics of variables.**

![Figure 3: EPU trends and coefficient estimation curve of $\beta_1^H (t)$.](a) (a) EPU trends. (b) The impact of EPU on the level of investment. (b)
changing market factors, which become fickle when uncertainty rises, thus inhibiting the investment efficiency of non-SOEs; whereas SOEs’ policy orientation compels them to fulfill tasks such as performance and closure targets for the government when EPU rises, leading to higher investment efficiency.
4.3. Comparative Analysis with Traditional Regression Models. Because the effect of economic policy uncertainty on firms’ investment behavior has obvious time-varying characteristics, the reliability of the functional regression estimation results becomes very important. We took the values involved in the discrete data and substituted them into a traditional linear regression model by comparing the regression coefficients with the nature of the effects in a continuous perspective. We also use (6) and (7) for comparative validation. The results are shown in Tables 5 and 6.

Table 5 shows that the coefficient of EPU is −0.02625 and is significant at the 1% level, indicating a significant decline in business investment when economic policy uncertainty rises, which is largely consistent with hypothesis H1. The coefficient of TQ∗EPU is 0.0074, indicating that EPU has a facilitating effect on the efficiency of firms’ investment, which is consistent with hypothesis H2, but the result is not significant. This is due to the fact that the results obtained from the regression based on discrete data only reflect the average impact, but the relationship between EPU and business investment is constantly changing over time; the specific time period characteristics cannot be observed using the traditional linear regression model. We have marked the confidence intervals at the 5% level of significance with dashed lines in Figure 4, which shows that there are indeed periods of nonsignificance around 2019, but the relationship between the impact of EPU and business investment efficiency is still significant in the whole.

The sample data were then subjected to grouped regression analysis according to the nature of the property rights, and the results are reported in Table 6. The test results show that EPU has a significant inhibitory effect on the level of investment in both state-owned and nonstate-owned enterprises. In terms of investment efficiency, EPU has a facilitating effect on the investment efficiency of state-owned enterprises and a dampening effect on the investment of nonstate-owned enterprises, which remains consistent with hypotheses H3 and H4. However, we can see from Figure 5 that the EPU’s promoting effect on the level of investment by SOEs changes from strong to weak and then to strong, while the effect on the level of investment by non-SOEs changes from promoting to inhibiting. Figure 6 shows that the effect of EPU on the investment efficiency of SOEs changes from promoting to inhibiting, while the inhibiting effect on the investment efficiency of non-SOEs changes from stronger to weaker. Overall, the above test results indicate that our approach has some credibility, while our findings reflect richer data information and complement existing studies.

5. Discussion
In essence, EPU is subject to macroeconomic fluctuations, which have a complex time-varying impact on business investment. We use a functional regression model in the paper to quantify the dynamic relationship between EPU and corporate investment. First of all, unlike traditional studies that explore the impact of EPU on corporate investment only from the perspective of discrete data observations, we use the FDA smoothing method to serialize discrete data into functional data and use functional data for functional regression analysis of EPU and corporate investment, which can express the information of the observed data continuously over the sample period. Even using annual and quarterly mixed-frequency data, we can accurately portray the impact curves of EPU and firm investment levels and investment efficiency. This innovation compensates for the shortcomings of the traditional econometric approach, which is limited by constraints and only yields partial information, thus improving the one-sidedness of the study results. The coefficient curves change continuously in terms of positivity, negativity, and significance, rather than being fully suppressive [81, 82] or promotional [83], for example, as shown in Figures 3 and 4. Next, in contrast to traditional panel regression models that estimate static parameters quantifying EPU and business investment, we reflect the significance levels of the regression coefficients in the resultant plots as well, which helps to analyze whether the effect of EPU on business investment is significant across time. As shown in Figure 3, the curve in panel b has been fluctuating around 0 during 2011–2016, indicating that the impact of uncertainty on corporate investment is no longer significant during this period due to the complex economic form and the fact that China is in transition, among others. In turn, EPU shows a significant boost to the level of business investment until 2011 and a significant dampening effect after 2016. In addition, we perform significance tests for each regression coefficient to obtain continuous parameter curves that facilitate analyzing the dynamic effects between different control variables on firms’ investments. While ROA has a significant side effect on the level of investment, as shown in Figure 2, CF presents a significant positive effect, and the remaining variables have a degree of inhibition with increasing uncertainty. Taken together, the functional regression model constructed by introducing FDA with reference to the existing literature expands the research perspective and dynamically quantifies the time-varying effects of EPU on the level of corporate investment as well as corporate investment efficiency, which also has a certain degree of explanatory effect on the controversial findings.

| Variables | Dependent variable: INVEST |
|-----------|---------------------------|
| EPU       | −0.02625** (−4.3441)      | −0.02733** (−2.8902) |
| TQ        | 0.10717 (0.5825)          | 0.07222 (0.2413)     |
| ROA       | −0.14008* (−2.5183)       | −0.14034* (−2.5209) |
| CF        | 0.70802*** (9.5606)       | 0.70787*** (9.5542)  |
| SIZE      | 0.13696** (2.8466)        | 0.13683** (2.8427)   |
| LEV       | 0.01965 (1.1587)          | 0.01961 (1.1560)     |
| Constant  | −0.25690 (−0.9027)        | −0.25076 (−0.8716)   |
| TQ∗EPU    |                          | 0.0074 (0.1481)      |

*Note. The t-statistic is in brackets; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.
The empirical results reveal that rising EPU has a statistically significant disincentive effect on the level of firm investment, but a significant promotion effect on firms’ investment efficiency, which is broadly consistent with the findings of previous studies. However, the relationship between EPU and enterprise investment has a significant time-varying effect, which is somewhat similar to the findings of Shao et al., meaning that there is a promoting effect on firm investment when economic policy uncertainty is low and a suppressing effect when uncertainty is high [84]. This finding emerged as a good explanation for the controversial findings in the existing studies. Some scholars believe that EPU promotes corporate investment behavior based on the fact that, at low levels of EPU, firms are more inclined to aggressive investment strategies due to their confidence in the market [85]. Some other scholars believe that EPU inhibits corporate investment behavior, based on the fact that corporate investors tend to be more conservative when EPU is high because they cannot accurately predict the market situation [86]. The findings can be interpreted roughly in the following ways. For one thing, when EPU is large, government policy guidance is weak, and firms’ investment behavior mainly relies on the market to make judgments, which reduces corporate management’s willingness to invest with inhibiting effects on investment behavior. At this time, the market plays a leading role in allocating resources, which is more efficient, and the company’s investment is more efficient. The second thing is that macroeconomic fluctuations, such as the development of fiscal and monetary policy, will lead to changes in interest rates, which will also affect the willingness of enterprises to invest, and corporate investors are hoping to gain benefits by improving the efficiency of investment. As economic growth continues to slow, the level of corporate investment begins to decrease continuously, and investment efficiency increases. Therefore, the inhibiting effect of rising EPU on business investment is identified.

After distinguishing between heterogeneity in property rights for group regressions on the relationship between EPU and firm investment levels and investment efficiency, we detect that variation in EPU contributes to differences in firms’ investment levels and investment efficiency among SOEs and non-SOEs, respectively. The group of non-SOEs shows a substantial decrease in investment level when EPU rises, while the group of SOEs still shows a boosting effect when EPU rises. Concerning investment efficiency, the rise in EPU has a boosting tendency for SOEs, while it shows a persistent dampening effect on non-SOEs. This may be attributed to the lack of policy guidance for non-SOEs and unclear policy orientation, leading them to be more sensitive to investment opportunities, which makes these firms’ investment levels drop significantly when EPU rises together with a tendency for the inhibitory effect of investment efficiency to diminish. On the other hand, state-owned enterprises are generally wholly owned by the government and are able to make investment decisions in accordance with policy guidelines when EPU rises, thus improving investment efficiency significantly.

### 6. Conclusions

Taking into account the complex influence of enterprise investment level and investment efficiency by macroeconomic fluctuation situation, we select 106 CSI 300 enterprises as sample data from 2007 to 2019 to analyze the impact of EPU on enterprise investment level and investment efficiency with the help of statistical research methods; meanwhile, we compare the differential impact of EPU on investment behavior and investment efficiency of state-owned enterprises with that of nonstate-owned enterprises through regression in groups. As an advantage of incorporating FDA to construct functional regression model, it can continuously capture the impact of time-varying covariates on response variables, which breaks through the traditional static analysis perspective and solves the controversial issue about the impact of EPU on enterprise investment. With the research based on our findings in this study, we get the following conclusions: there is a dynamic influence relationship between macro-EPU and microfirm investment behavior over time and the same relationship with firm investment efficiency. During the gradual increase of EPU, the effect on firms’ investment behavior changes from a significant promoting effect to a significant inhibiting effect, while the effect on firms’ investment efficiency

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**Table 6: Regression results in groups.**

| Variables | State-owned | Nonstate-owned | State-owned | Nonstate-owned |
|-----------|-------------|----------------|-------------|----------------|
| EPU       | −0.04453*** (−5.6199) | −0.00808 (−0.2350) | −0.03761** (−3.1166) | 0.00761 (0.5708) |
| TQ        | −0.10211 (−1.0858) | −0.13493* (−2.1061) | −0.11213 (−0.2290) | −0.06293 (−0.6648) |
| ROA       | −0.11701 (−1.3855) | 0.05190 (0.2546) | −0.11909 (−1.8659) | 0.05727 (0.2808) |
| CF        | 0.62716*** (6.0758) | 0.65788*** (6.1262) | 0.62492*** (6.0502) | 0.65082 (6.0482) |
| SIZE      | 0.18542** (2.6163) | −0.05315 (−0.6341) | 0.19063** (2.6765) | −0.05535 (−0.6602) |
| LEV       | 0.01934 (0.8947) | 0.02290 (0.2442) | 0.01872 (0.8650) | 0.02010 (0.2142) |
| Constant  term | −0.41364 (−0.9271) | 0.98252* (2.0650) | −0.47952 (−1.0548) | 0.95258 (1.9985) |
| TQ+EPU   | −0.01429 (0.7607) | −0.01463 (−1.0333) |                       |                 |
| Sample size | 56         | 50             | 56          | 50             |
| Adjusted R2 | 0.11      | 0.07           | 0.11        | 0.07           |

*Note. The t-statistic is in brackets; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
changes from a significant inhibiting effect to a significant promoting effect. Moreover, the effect of EPU on firms’ investment level and investment efficiency has a differential impact between state-owned and nonstate-owned firms, with the rising EPU having a greater inhibitory effect on nonstate-owned firms’ investment level but a greater promotional effect on state-owned firms’ investment efficiency.

Based on the research results, we have made the following policy recommendations. Firstly, the government should strengthen its communication efforts with enterprises before adjusting the economic policies related to them. As economic policies are important macroeconomic control tools of the country, uncertainty mostly comes from the fact that enterprises do not know when the government will issue which economic policies and cannot correctly understand the government’s intention of formulating economic policies. Therefore, when the government stabilizes economic development by adjusting economic policies, it should take into account the affordability of micro-enterprises to prevent the loss of their interests due to too many uncertainties. Secondly, the influence of government policies at different levels in China is very wide, and there is more intervention by the visible hand of the government, which makes state-owned enterprises more dependent on economic policies. At the same time, we should define the boundaries of the government’s visible hand and protect the economic interests of non-SOEs from excessive influence so that the government can return to its role of escorting the market economy. Finally, for different types of enterprises, the government should adjust its policies in a targeted manner to ensure the economic development of enterprises towards high quality. The uncertainty brought by the macroenvironment brings nonstate enterprises “afraid to invest” and wait-and-see mood. The economic strength of nonstate enterprises is relatively weak, and there is information asymmetry, which leads to a certain lag time in response to economic policies. For this reason, the government ought to provide more protection to nonstate enterprises and offer some support to them when adjusting economic policies. Under reasonable circumstances, it should make targeted regulation for nonstate enterprises to weaken the impact of economic policy uncertainty on nonstate enterprises so as to protect the legitimate rights and interests of nonstate enterprises.

Even though we have obtained new findings and some constructive conclusions in examining EPU on firm investment level and investment efficiency, it is still a preliminary exploration, and there is much room for further discussion. Foremost, we introduced a functional-type approach to empirically explore the dynamic effects of macro-variables on microfirms, but the mechanism of the effects was not explored. Then, the sample of the study is selected from the CSI 300 firms, where prospective studies can specifically examine the impact of EPU on the investment of listed firms in a particular industry. Moreover, the channels through which economic policy uncertainty affects corporate investment are complex, and follow-up studies can add moderating or mediating variables to the model to analyze the extent of EPU’s impact on corporate investment situations.

Data Availability
All data generated or analyzed during this study are included in this paper.

Conflicts of Interest
The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments
This research was supported by the Natural Science Foundation of China (71701201) and the Natural Science Foundation of Jiangsu Province (BK20170268).

References
[1] Y. Wang, C. R. Chen, and Y. S. Huang, “Economic policy uncertainty and corporate investment: evidence from China,” Pacific-Basin Finance Journal, vol. 26, pp. 227–243, 2014.
[2] F. Y. Li and M. Z. Yang, “Does economic policy uncertainty inhibit firm investment? -- An empirical study based on China’s economic policy uncertainty index,” Financial Research, vol. 4, pp. 115–129, 2015.
[3] W. Kang, K. Lee, and R. A. Ratti, “Economic policy uncertainty and firm-level investment,” Journal of Macroeconomics, vol. 39, pp. 42–53, 2014.
[4] G. Parigi, M. E. Botempi, and R. Golinelli, “Why demand uncertainty curbs investment: evidence from a panel of Italian manufacturing firms,” Journal of Macroeconomics, vol. 32, no. 1, pp. 218–238, 2010.
[5] M. Bianco, M. E. Bontempi, and R. Golinelli, “Family firms’ investments, uncertainty, and opacity,” Small Business Economics, vol. 40, no. 4, pp. 1035–1058, 2013.
[6] D. Papanikolaou and V. Panousi, “Investment, idiosyncratic risk, and ownership,” Social Science Electronic Publishing, vol. 67, no. 3, pp. 1113–1148, 2012.
[7] B. Julio and Y. Yook, “Political uncertainty and corporate investment cycles,” The Journal of Finance, vol. 67, no. 1, pp. 45–83, 2012.
[8] M. B. Frye and D. T. Pham, “Economic policy uncertainty and board monitoring: evidence from CEO turnovers,” Journal of Financial Research, vol. 43, no. 3, pp. 675–703, 2020.
[9] S. R. Baker, N. Bloom, and S. J. Davis, “Measuring economic policy uncertainty,” Quarterly Journal of Economics, vol. 131, no. 4, pp. 1593–1636, 2016.
[10] S. Akrom, E. Demir, and J. M. D-Esteban, “Economic policy uncertainty and corporate investment: evidence from the U.S. Hospitality industry,” Tourism Management, vol. 77, Article ID 104019, 2020.
[11] P. Jan and S. Alexander, “On the time-varying effects of economic policy uncertainty on the US economy,” Oxford Bulletin of Economics & Statistics, vol. 82, no. 5, pp. 1217–1237, 2020.
[12] P. G. Rao, H. Yue, and G. H. Jiang, “A study on economic policy uncertainty and firms’ investment behavior,” The World Economy, vol. 40, no. 2, pp. 27–51, 2017.
[13] F. Luo, "A study on economic policy adjustment and financialization of corporate investment," *Business and Economic Research*, vol. 21, pp. 160–163, 2019.

[14] G. W. Xu, Z. Sun, and X. Liu, "The impact of economic policy uncertainty on firms’ investment structure bias--empirical evidence based on China’s EPU index," *Management Review*, vol. 32, no. 1, 2020.

[15] J. O. Ramsay and J. I. Dalzell, "Some tools for functional data analysis," *Journal of the Royal Statistical Society: Series B*, vol. 53, no. 3, pp. 539–572, 1991.

[16] T. T. Yu and X. L. Lu, “Analyzing the structure and market development of online group buying market with function-based data,” *Statistics and Information Forum*, vol. 28, no. 3, pp. 68–75, 2013.

[17] R. Q. Zhou, J. L. Li, and A. Q. Dong, "Research on the intensity of stock capital flow based on function-based data analysis," *Journal of Taiyuan University of Science and Technology*, vol. 42, no. 3, 2021.

[18] M. M. Wang and H. Ding, "Functional nonparametric regression models and its applications in finance," *Journal of Chuzhou College*, vol. 5, pp. 18–20, 2016.

[19] H. Cheng and Z. Yan, "Dynamic analysis of urban and rural consumption functions based on functional regression models," *Statistics and Decision Making*, vol. 37, no. 11, pp. 80–84, 2021.

[20] J. Suhaila, A. A. Jemain, M. F. Hamdan, and W. Zin, “Comparing rainfall patterns between regions in Peninsular Malaysia via a functional data analysis technique," *Journal of Hydrology*, vol. 411, no. 3–4, pp. 197–206, 2011.

[21] M. L. Juan and A. B. Santiago, "Functional data analysis, a new approach to aligning three-way liquid chromatographic with fluorescence detection data," *Microchemical Journal*, vol. 142, pp. 219–228, 2018.

[22] B. Ufuk and M. Y. Zaher, "Drought interval simulation using functional data analysis," *Journal of Hydrology*, vol. 579, Article ID 12441, 2019.

[23] J. O. Ramsay and B. W. Silverman, *Functional Data Analysis*, Springer, New York, NY, USA, 2nd edition, 2005.

[24] X. K. Chen, H. A. L. Cao, Y. W. Shan, and S. Taylor, "Australian policy uncertainty and corporate investment," *Pacific Basin Finance Journal*, vol. 61, Article ID 101341, 2020.

[25] M. Ilyas, A. Khan, M. Nadeem, and M. T. Suleman, "Economic policy uncertainty, oil price shocks and corporate investment: evidence from the oil industry," *Energy Economics*, vol. 97, Article ID 105193, 2021.

[26] F. Hou, W. J. Tang, H. B. Wang, and H. Xiong, "Economic policy uncertainty, marketization level and firm-level inefficient investment: evidence from Chinese listed firms in energy and power industries," *Energy Economics*, vol. 100, no. 2, Article ID 105353, 2021.

[27] R. Wang, B. Yu, X. M. Liu, and Z. Wang, "Research on the relationship between economic policy uncertainty and corporate investment behavior," *Friends of Accounting*, vol. 12, pp. 106–111, 2020.

[28] Q. Y. Du, Z. Y. Li, and Y. W. Yu, "Bilateral economic policy uncertainty and firms’ outward direct investment," *Zhejiang Social Sciences*, vol. 9, pp. 15–23, 2020.

[29] P. H. Luis, P. Javier, and F. Gabriel, "Monetary policy and corporate investment: a panel-data analysis of transmission mechanisms in contexts of high uncertainty," *International Review of Economics & Finance*, vol. 75, pp. 609–624, 2021.

[30] R. McDonald and D. Siegel, "The value of waiting on invest," *Quarterly Journal of Economics*, vol. 101, no. 4, pp. 707-708, 1986.

[31] R. K. Dixit and R. S. Pindyck, *Investment under Uncertainty*, pp. 160–298, Princeton University Press, Princeton, NJ, USA, 1994.

[32] R. Hartman, "The effects of price and cost uncertainty on investment," *Journal of Economic Theory*, vol. 5, no. 2, pp. 258–266, 1972.

[33] R. S. Pindyck, "Adjustment costs, uncertainty, and the behavior of the firm," *The American Economic Review*, vol. 72, no. 3, pp. 415–427, 1982.

[34] A. B. Abel, "Optimal investment under uncertainty," *The American Economic Review*, vol. 73, no. 1, pp. 228–233, 1983.

[35] S. J. Nickell, "The investment decisions of firms," *Nisbet*, Cambridge University Press, Cambridge, MA, USA, 1978.

[36] B. Jeong, "Policy uncertainty and long-run investment and output across countries," *International Economic Review*, vol. 43, no. 2, pp. 363–392, 2002.

[37] Y. C. Peng, X. Han, and J. J. Li, "Economic policy uncertainty and corporate financialization," *China Industrial Economics*, vol. 1, pp. 137–155, 2018.

[38] M. Campello, J. Graham, and C. Harvey, "The real effects of financial constraints: evidence from a financial crisis," *Journal of Financial Economics*, vol. 97, pp. 470–487, 2010.

[39] H. Gulen and M. Ion, "Policy uncertainty and corporate investment," *Review of Financial Studies*, vol. 29, no. 3, pp. 523–564, 2016.

[40] C. Y. Wang, X. L. Zhang, and H. N. Bao, "Economic policy uncertainty and dynamic adjustment of firms’ capital structure and stable leverage," *China Industrial Economics*, vol. 12, pp. 134–151, 2018.

[41] T. B. Mark, A. R. Scott, and G. S. Richard, "The relation between corporate financing activities, analysts’ forecasts and stock returns," *Journal of Accounting and Economics*, vol. 42, no. 1–2, pp. 53–85, 2006.

[42] J. Wurgler, "Financial markets and the allocation of capital," *Journal of Financial Economics*, vol. 58, no. 1–2, pp. pp187–214, 2000.

[43] A. Chari and P. B. Henry, "Firm-specific information and the efficiency of investment," *Journal of Financial Economics*, vol. 87, no. 3, pp. 636–655, 2008.

[44] S. M. Chen, Z. Sun, S. Tang, and D. H. Wu, "Government intervention and investment efficiency: evidence from China," *Journal of Corporate Finance*, vol. 17, no. 2, pp. 259–271, 2011.

[45] G. H. Jin, Z. Y. Liu, and G. R. Hua, "Policy uncertainty and enterprise investment -- an empirical study based on strategic emerging industries," *Management Review*, vol. 28, no. 9, pp. 2–16, 2016.

[46] S. L. Li, S. J. Chang, and D. K. Si, "Monetary policy, economic uncertainty and corporate investment efficiency," *International Figure Skating*, vol. 7, pp. 86–96, 2021.

[47] L. Dong, "Economic policy uncertainty, managerial confidence and firm investment efficiency," *Statistics and Decision Making*, vol. 37, no. 10, pp. 165–169, 2021.

[48] Q. Zhang, F. X. Ji, and D. Pan, "Policy uncertainty, bank credit supply and enterprise investment," *Chinese Soft Science*, vol. 4, no. 10, 2021.

[49] W. F. Xie and S. H. Chen, "Economic policy uncertainty, accounting robustness and firm investment efficiency - evidence from Chinese A-share listed private firms," *Technology Economics*, vol. 39, no. 11, pp. 118–126, 2020.

[50] C. E. Bai, Q. Liu, and J. Lu, "Corporate governance and market valuation in China," *Journal of Comparative Economics*, vol. 32, no. 4, pp. 599–616, 2004.
[51] W. Sun, G. Xiao, and X. Yang, "Effect of return to capital on investment ratio: a comparative analysis among China, US, and Japan," *The World Economy*, vol. 6, pp. 3–24, 2010.

[52] A. Durnev, *The Real Effects of Political Uncertainty: Elections and Investment Sensitivity to Stock Prices*, The University of Iowa working paper, Oakdale, CA, USA, 2012.

[53] A. Bonaime, H. Gulen, and M. Ion, "Does policy uncertainty affect mergers and acquisitions?" *Journal of Financial Economics*, vol. 9, pp. 531–558, 2018.

[54] L. Pastor and F. Veronesi, "Political uncertainty and risk premia," *Journal of Financial Economics*, vol. 110, pp. 520–545, 2013.

[55] M. O. Keefe and J. Tate, "Is the relationship between investment and conditional cash flow volatility ambiguous, asymmetric or both?" *Accounting and Finance*, vol. 53, no. 4, pp. 913–947, 2013.

[56] C. C. Zhang and D. C. Yang, "Monetary policy, investor sentiment and corporate investment behavior," *Journal of Central University of Finance & Economics*, vol. 12, pp. 57–68, 2015.

[57] D. Chen, S. Khan, and X. Yu, "Government intervention and investment comovement: Chinese evidence," *Journal of Business Finance & Accounting*, vol. 40, no. 3-4, pp. 564–587, 2013.

[58] D. Mei, "Government intervention, soft budget constraint, and over-investment—Evidence based on state-owned listed companies in China from 2004 to 2006," *Soft Science*, vol. 23, no. 11, pp. 114–117, 2009.

[59] Y. J. Hao, B. Q. Kang, and D. Y. Huang, "The impact of economic policy uncertainty on investment in small and medium-sized enterprises in China," *Technology and Economics*, vol. 30, no. 6, pp. 96–100, 2017.

[60] W. Huang, F. Jiang, and Z. Liu, "Agency cost, top executives’ overconfidence, and investment-cash flow sensitivity — evidence from listed companies in China," *Pacific-Basin Finance Journal*, vol. 19, no. 3, pp. 261–277, 2011.

[61] J. L. Li, J. C. Dong, and Q. X. Zhang, "Economic policy uncertainty, financing constraints and corporate investment," *Statistics and Information Forum*, vol. 34, no. 10, pp. 73–83, 2019.

[62] R. K. Morck, M. D. Yavuz, and B. Y. Yeung, "State-controlled banks and the effectiveness of monetary policy," *General Information*, vol. 51, no. 3, pp. 1–15, 2013.

[63] Q. Y. Song, X. Li, and L. Qian, "Economic policy uncertainty and corporate lending costs," *Financial Research*, vol. 7, pp. 57–75, 2019.

[64] B. C. Raul, M. Burkert, A. Davila, and O. Daniel, "Shareholder protection: the role of multiple large shareholders," *Social Science Electronic Publishing*, vol. 24, no. 2, pp. 105–129, 2016.

[65] H. Khanh, N. Cuong, and H. L. Zhang, "How does economic policy uncertainty affect corporate diversification?" *International Review of Economics & Finance*, vol. 72, pp. 254–269, 2021.

[66] D. X. Yang, S. Z. Xu, and B. N. Wei, "Economic policy uncertainty and corporate OFDI: discouragement or promotion?" *Contemporary Finance & Economics*, no. 2, pp. 108–119, 2019.

[67] J. Li, W. W. Cao, Y. Qiao, and Z. Pan, "Business expectation gap, risk-taking level and innovation sustainability - a comparative study of private and non-private enterprises," *China Soft Science*, no. 2, pp. 140–148, 2018.

[68] X. Li and X. X. Li, "Economic policy uncertainty and risk-taking level of SMEs - a study based on asset specificity perspective." *Journal of Zhongzhou University*, vol. 38, no. 6, pp. 28–32+39, 2021.

[69] P. G. Li and M. Xiao, "CEO tenure and corporate capital investment," *Financial Research*, vol. 2, pp. 127–141, 2012.

[70] H. Iwata and K. Okada, "How does environmental performance affect financial performance? Evidence from Japanese manufacturing firms," *Ecological Economics*, vol. 70, pp. 1691–1700, 2011.

[71] B. Villalonga, M. Trujillo, A. Guzman, and N. Caceres, "What are boards for? Evidence from closely held firms in Colombia," *Financial Management*, vol. 48, pp. 537–573, 2019.

[72] Y. L. Han, Z. X. Zhao, and B. B. Shi, "Financial development, monetary policy changes and corporate investment efficiency—an empirical study based on the perspective of corporate financing constraints," *Economics and Management Review*, vol. 37, no. 4, pp. 30–43, 2021.

[73] S. X. Zeng, X. D. Xu, H. T. Yin, and C. M. Tam, "Factors that drive Chinese listed companies in voluntary disclosure of environmental information," *Journal of Business Ethics*, vol. 109, pp. 309–321, 2012.

[74] A. Bernard, A. Moxnes, and Y. Saito, "Production networks, geography, and firm performance," *Journal of Political Economy*, vol. 127, pp. 639–688, 2019.

[75] N. Katmon, Z. Mohamad, N. N. Mat, and O. Farooque, "Comprehensive board diversity and quality of corporate social responsibility disclosure: evidence from an emerging market," *Journal of Business Ethics*, vol. 157, pp. 1–35, 2019.

[76] P. Craven and G. Wahba, "Smoothing noisy data with spline functions: estimating the correct degree of smoothing by the method of generalized cross-validation," *Numerische Mathematik*, vol. 31, no. 4, 1979.

[77] X. M. Deng, "The impact of economic policy uncertainty on China’s listed companies—a literature review," *China Business Journal*, vol. 19, pp. 113-114, 2019.

[78] F. H. Wen, C. Li, H. Sha, and L. G. Shao, "How does economic policy uncertainty affect corporate risk-taking? Evidence from China," *Finance Research Letters*, vol. 41, Article ID 101840, 2020.

[79] Y. Y. Xue, "The effects of property rights nature and risk-taking level on corporate overinvestment," *China Market*, no. 7, pp. 70–73, 2021.

[80] Y. M. Zhao and J. M. He, "Debt maturity mismatch, risk-taking level and corporate investment efficiency," *Economic Issues*, vol. 10, pp. 26–33, 2021.

[81] B. S. Bernanke, "Irreversibility, uncertainty, and cyclical investment," *Quarterly Journal of Economics*, vol. 98, no. 1, pp. 85–106, 1983.

[82] N. E. Magud, "On asymmetric business cycles and the effectiveness of counter-cyclical fiscal policies," *Journal of Macroeconomics*, vol. 30, no. 3, pp. 885–905, 2008.

[83] A. B. Abel and J. C. Eberly, "A unified model of investment decision directornetwork," *China Soft Science*, vol. 23, pp. 57–75, 2012.

[84] N. E. Magud, "On asymmetric business cycles and the effectiveness of counter-cyclical fiscal policies," *Journal of Macroeconomics*, vol. 30, no. 3, pp. 885–905, 2008.

[85] A. B. Abel and J. C. Eberly, "A unified model of investment under uncertainty," *The American Economic Review*, vol. 84, no. 5, pp. 1369–1384, 1994.

[86] Y. Z. Zhang and X. Q. Zhao, "Study on the impact of economic policy uncertainty on business investment," *Quantitative Economic Research*, vol. 1, p. 18, 2019.