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ECONOMIC POLICY UNCERTAINTY AND CORPORATE INVESTMENT DECISIONS: EVIDENCE FROM TURKISH MANUFACTURING FIRMS*

EKONOMİ POLİTİKASI BELİRSİZLİĞİ VE KURUMSAL YATIRIM KARARLARI: TÜRK İMALAT SEKTÖRÜ FİRMALARI ÖRNEĞİ

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Abstract

The aim of this study is to investigate the short – and long-term impacts of economic policy uncertainty (EPU) on the corporate investment decisions of Turkish manufacturing firms listed on the Borsa Istanbul (BIST). The sample consists of 103 manufacturing firms and the data period is from 2005 Q1 to 2023 Q4. We use the global EPU (GEPU) index to proxy for uncertainty. We use panel data analysis and estimate the regression parameters using both the fixed effects model and the fixed-effect quantile regression model. Our findings indicate a negative and statistically significant impact of GEPU on corporate investment decisions. Moreover, in the long-term, this negative impact persists and continues to hold significant. The findings are in line with the predictions of the real options theory, the assumptions of which are irreversibility and forward-looking nature of investments. When firms experience a positive uncertainty shock in the investment environment, they prefer to postpone their investments or disinvest. Our findings have some major implications. First, companies should incorporate EPU into their investment decisions to time their investment activities. Second, EPU can have persistent and prolonged impacts that create fluctuations in corporate investment. Third, companies should consider global economies' EPU besides local EPU when making investment decisions as the empirical results of this study show.

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Öz

Bu çalışmanın amacı ekonomi politikası belirsizliğinin (EPU) Borsa İstanbul'da (BIST) işlem gören firmaların yatırım kararları üzerindeki etkisini incelemektir. Örneklem 103 adet imalat sektörü firmasından oluşmakta olup çalışmada 2005-2023 yılları arasındaki çeyreklik veriler kullanılmıştır. Belirsizlik göstergesi olarak Global Ekonomi Politikası Belirsizlik Endeksi (GEPU) seçilmiştir. Yöntem olarak panel veri analizi kullanılmış ve regresyon parametreleri hem Sabit Etkiler hem de Sabit Etkili Kantil Regresyon modelleriyle tahmin edilmiştir. Analiz sonuçlarına göre kısa dönemde GEPU'nun şirketlerin kurumsal yatırım miktarına olan etkisi anlamlı ve negatiftir. Bu negatif etki uzun dönemde de anlamlı ve negatif kalmaya devam etmiştir. Bulgular, yatırımların geri döndürülemez ve ileriye dönük olduğuna dair varsayımlarda bulunan Reel Opsiyonlar Teorisi ile uyumludur. Eğer firmalar yatırım ortamında pozitif bir belirsizlik şokuyla karşılaşırsa yatırımlarını ya ertelemeyi ya da yapmamayı tercih etmektedirler. Çalışmadaki bulguların çıkarımları şu şekildedir: Şirketler yatırım kararı verirken yatırımı doğru bir zamanda yapabilmek için EPU'yu göz önünde bulundurmalıdırlar. EPU'nun kurumsal yatırımlar üzerindeki etkisi hemen geçmemekte ve belirli bir süre devam etmektedir. Bu durum kurumsal yatırımlarda dalgalanmalara yol açmaktadır. Şirketler, analiz sonuçlarının da gösterdiği üzere, yatırım kararı alırken sadece ülkelerindeki EPU'yu değil aynı zamanda global ekonomilerin EPU'larını da hesaba katmalıdırlar.
Anahtar Kelimeler: Ekonomi politikası belirsizliği, reel opsiyonlar, Oi-Hartman-Abel etkisi, kurumsal yatırım kararları, Türkiye
JEL Sınıflandırılması: E29, G30, G31

1. Introduction

German car manufacturer Volkswagen decided to build a car plant in Türkiye in 2018. After postponing its investment decision multiple times over a period of five months, Volkswagen eventually announced that it had abandoned its plans to invest in Türkiye and increase production capacity in Slovakia (Lopatka, 2020). This case demonstrates how investment choices are closely linked to changes in daily political and economic conditions, highlighting the significant impact of uncertainty on corporate investment (CI) decisions. Four years later after the Volkswagen, the Chinese car manufacturing company, BYD, agreed to invest in the same place, Manisa, about $1 billion to open a plant that produces electrical vehicle and plug-in hybrid vehicle (Tavsan, 2024).

Uncertainty has a broad impact on many variables including stock markets, cryptocurrency markets, and asset prices such as green and brown energy stocks (Gemici, 2020; Karaca, 2025; Bouri et al., 2022). Economic uncertainty is described by inadequate knowledge to evaluate economic occurrences in confidence (Adedoyin et al., 2022: 2). Uncertainty shocks can cause investors to delay or even halt investments due to adjustment costs and the partial irreversibility of the investments (Stein & Stone, 2013). Companies are hesitant to commit their resources to long-term projects in a risky business environment. More information is required to resolve current uncertainty in the environment; however, in this case, there is a trade-off between the benefits of waiting for information and the loss of cash flow while postponing investments. This trade-off is particularly relevant for strategic R&D investments, where the strategic value of early commitment matters significantly (Trigeorgis, 2002).

The impact of uncertainty on CI decisions can be positive or negative depending on the theoretical perspective. Baddeley (2003) notes that the debate on the association between investment and uncertainty began with the claim that they are positively linked. The positive investment-uncertainty relationship is recognized as the Oi-Hartman-Abel effect (Oi, 1961; Hartman, 1972; Abel, 1983). In contrast, the real options theory, when considering the irreversibility and forward-looking nature of investments, estimates a negative relationship between investment spending and uncertainty.

Economic policy uncertainty (EPU) causes unexpected parameter changes that influence the economic environment (Wang et al. 2014). These changes affect the amount of CI via the required rate of return. Furthermore, EPU raises systematic risk, leading to an increase in the rate of return that impacts the investment threshold. Many empirical papers have found a negative association between EPU and CI (Dreyer & Schulz, 2022; Gulen & Ion 2016; Jirasavetakul & Spilimbergo 2018) although the impact of uncertainty on CI changes from country to country. For example, Wu et al. (2020) investigated firms listed on the Australia Securities Exchange and found a positive and significant association between EPU and CI. As the evidence on empirical studies about the impact of EPU on CI is mixed, it is worth analyzing this association empirically.

The aim of this paper is to examine the impact of EPU on investment decisions of publicly listed Turkish manufacturing firms. To do so, we proxy for uncertainty using the global EPU (GEPU) index. In the sample, we use quarterly financial statements of 103 manufacturing firms listed in Borsa Istanbul (BIST) from 2005 Q1 to 2023 Q4. We employ panel data analysis and estimate the regression coefficients using the fixed effects model with Driscoll-Kraay (1998) standard errors and the Machado & Santos Silva (2019) quantile regression model.

We chose the Turkish market for the following reasons. First, Türkiye is an emerging market that requires CI to foster its economic development. Therefore, firms' investment behavior under uncertainty becomes an important criterion to consider when making investments. Second, the nexus among macroeconomic variables like inflation, interest rates, and exchange rates in Türkiye creates a risky business environment for manufacturing companies. It is interesting to analyze their investment behavior under uncertainty as they may become risk lovers under these conditions to benefit from opportunities for high profitability. Additionally, the volatile environment may make them more competitive in dynamic markets.

The empirical results of this study indicate that, in line with the findings in the literature on this topic, the impact of EPU on Turkish manufacturing firms' CI decisions is significantly negative. This result aligns with the predictions of the real options theory, because irreversibility of capital leads to the so-called option value of waiting, which increases with uncertainty (Schauer, 2019). The results stay robust when alternative EPU indices are used, and endogeneity is controlled. In the long-run, the impact of EPU on the CI level remains significant and negative.

The contribution of this paper is threefold. First, emerging countries such as Türkiye needs foreign direct investment for development; however, local firms' investment behavior under uncertainty is as important as foreign firms' behavior. This paper sheds light on publicly traded, mostly local firms' investment behavior under uncertainty. Second, in contrast to most empirical studies on this topic, which focused on the short-term impact of EPU on CIs (Jirasavetakul & Spilimbergo, 2018; Vo & Nguyen, 2023; Wu et al., 2020), we also analyze the long-term impact. Third, along with the fixed effects model, we investigate the association between uncertainty and CI using quantile regression, which allows outliers in the data.

The rest of the paper is organized as follows. In Section 2, we discuss investment theories under uncertainty and characteristics of investment decisions. In Section 3, we present our panel dataset and methodology. In Section 4, we provide our main results and discuss our findings. Section 5 concludes and presents some implications for our findings.

2. Theoretical Approaches and Previous Research

Marshallian Law, or the net present value (NPV) rule, proposes that if the present value of future net cash flows of an investment is higher than initial cost of it, the decision to invest should be positive. The traditional investment evaluation methods, i.e. the NPV rule, payback period, and internal rate of return, have weaknesses, such as "the timing of investment decisions, irreversibility of investment expenditure, ignorance of outcome uncertainty and ignorance of managerial flexibility" (Topçu, 2020: 35-36). Specifically, NPV assumes that either the investment is reversible or even if it is irreversible, there is not a choice for firm to postpone the investment (Dixit & Pindyck, 1994). According to the aforementioned methods, firm's decision-making rule is linear, and the future return on investment is not a stochastic but a deterministic variable. However, uncertainties in real life can disrupt the linearity of this decision-making. These uncertainties can affect CI either positively or negatively, relying on the underlying theories and assumptions.

In the literature, the positive relationship between investment and uncertainty is referred to as the Oi-Hartman-Abel effect. This approach suggests that increased price uncertainty cause competitive risk-neutral firms to expand their investment levels because of Jensen's inequality (Ferderer, 1993). The increased uncertainty in output prices raises the expected future marginal revenue product, thereby stimulating an increase in current investments, irrespective of the marginal adjustment cost function's curvature (Abel, 1983). Moreover, the flexibility of firms adjusting their inputs after the investment decision is given causes firms to be risk-tolerant under uncertainty. Firms increase their activities to benefit from good outcomes and decrease them to refrain from negative impacts of bad outcomes. This argument is valid if the markets are perfectly competitive. Abel (1983) noted that the positive impact of uncertainty on investment is sensitive to assumptions like perfect competition and constant returns to scale, too.

To counter the weaknesses of these theories, the real options theory which optimizes managerial choices under uncertainty is developed. Initiated by Black & Scholes (1973) and Merton (1973), the option pricing theory has been studied by many academics in the literature. Real options are future investment opportunities, or "call options" (Myers, 1977). They provide managers the option to invest now or wait for market conditions to turn favorable. During the "wait and see" period, any new information that decreases uncertainty contributes to a better-informed future decision that reduces premature investment. But the higher value gained from waiting also requires a higher critical investment threshold. In other words, the required investment cost should be lower than the project value at a significant amount before investing and giving up the option to wait (Trigeorgis, 2002). This implies that higher uncertainty causes a lower or delayed investing.

The real options theory proposes that the uncertainty's negative impact on investment expenditure is influenced by the firm's investment irreversibility degree. Firms that have more irreversible investment projects are more likely to postpone their investments when they experience a common positive shock (Gulen & Ion, 2016). Conversely, uncertainty shocks do not have an impact on completely reversible investment projects, which do not create a motivation to wait (Gulen & Ion, 2016). Uncertainty, together with irreversibility, raises the user cost of capital and lowers the elasticity of decisions to invest and the investment level (Bianco et al., 2013).

The following equation series explains the firm's irreversible investment behavior under uncertainty, respectively. Equation (1) shows the calculation of the total expected return to investment, composed of discounting of future returns based on different information states (Bernanke, 1983: 89):

$$R_{k,s} = r_{k,s} + \beta E_s R_{k,s+1} \quad \text{with} \quad s = t, t+1, \dots, T, \tag{1}$$

where β is a scalar discount factor and $R_{k,s}$ is the sum of the current return $(r_{k,s})$ and the expected value of future returns, discounted to the present time (*t*) with β .

The goal of the investor is to maximize the expected total return from the irreversible investment project. Specifically, the investor should select investment project k if and only if it has the highest total return among alternatives and its current return exceeds the option value. The relevant equations are provided below (Bernanke, 1983: 90):

$$R_{kt}^{j} \geq max\left(R_{1t}^{j}, \dots, R_{mt}^{j}, V_{t}^{j}\right), \tag{2}$$

where

$$V_s = \beta E_s\{\overline{max}(R_{1,s+1}, \dots, R_{m,s+1}, V_{s+1})\} \qquad (n_s \times 1) \tag{3}$$

and

$$V_T = (0,0, \dots, 0)^{transpose} \qquad (n_T \times 1). \tag{4}$$

Furthermore, the willingness to invest in project k at time t will depend on the average expected severity of bad news that may come in the following period (Bernanke, 1983: 90). The option value of the irreversible investment when bad news is incorporated is as follows (Bernanke, 1983: 91):

$$\beta E_t\left(x_{k,t+1} \middle| x_{k,t+1} \geq 0\right) = Z_{kt}^j \tag{5}$$

with

$r_{k,t}^j \geq jth$ element of the Equation (5).

$r_{k,t}^j$ represents the current return of investment project k at time t in state j, and Z_{kt}^j is the option value related with investment project k at time t in state j. The investor compares the current return of the project to Z_{kt}^j to evaluate whether to accept the most profitable investment or postpone commitment and holds an option to reevaluate depending on the future information.

Our analysis of the impact of EPU on CI is motivated by predictions of the real options theory. The user cost of capital is modified to take into account irreversibility and uncertainty. Together with irreversibility, the user cost of capital increases and the elasticity of decisions to invest and the investment level decreases due to uncertainty (Bianco et al. 2013). According to the real options theory, the impact of uncertainty on investment is negative. However, if the investment is not irreversible, the association between CI decisions and uncertainty may be positive due to the existence of embedded options created within the project (Trigeorgis, 2002).

Empirical studies also confirm the negative effect of uncertainty on investments (Bernanke 1983; Bloom 2000; Carlsson 2007; Ghosal & Loungani 2000; Kim et al., 2023; Li & Sun 2024; McDonald & Siegel 1986; Piao & Jung 2023). The studies that examine the impact of uncertainty on CI by using the EPU index as a proxy for uncertainty reached mostly the same conclusion that there is a negative association between the two variables (Akron et al, 2020; Altaf, 2022; Chen et al., 2019; Farooq et al., 2022; Jing et al., 2023; Meng et al., 2023; Trinh, 2024).

Grounded in the estimations of the real options theory and the findings of the previous studies, we construct the following first hypothesis (Topçu, 2020: 65):

H_1: EPU has a negative effect on CI decisions of Turkish manufacturing firms listed in BIST.

We also investigate the long-term impact of EPU on CI decisions. In the long-run, as firms gain flexibility to adjust their inputs after investment decisions are made, they may become less risk averse. Based on this argument, we construct the following second hypothesis (Topçu, 2020: 65):

H_2: The effect of EPU on CI decisions changes over time.

3. Data and Methodology

3.1. Data

To measure the impact of EPU on CI, we use a sample of quarterly financial statements from BIST-listed manufacturing firms covering the period from 2005 Q1 to 2023 Q4. The dataset is an unbalanced panel because the dependent variable has some missing values. Following the literature (e.g. see Gulen & Ion, 2016; Jirasavetakul & Spilimbergo, 2018), we preferred quarterly data rather than annual data.

Manufacturing firms tend to have high levels of physical assets and disinvest in substantial, discrete amounts of physical capital in downturns due to their high adjustment costs (Gulen & Ion, 2016: 22). According to the regulations of the Capital Market Board of Türkiye, all listed firms on BIST must disclose their financial statements. The list of our sample firms comes from the Public Disclosure Platform's website. After excluding firms for which data is not available for the given period, our sample comprises 103 firms.

Variable Definitions

We consider an EPU variable, five firm-level variables [CI, operating cash flow (OCF), Tobin's Q, gross sales growth and firm size], three macroeconomic variables (GDP growth, nominal interest rates and current account balance), and one calendar quarter dummy variable to analyze the impact of uncertainty on CI decisions. CI, the dependent variable, which is proxied by CAPEX normalized by total assets is one of the prominent proxies that can be used to measure CI (See Gulen & Ion, 2016; Wang et al., 2014). However, one should note that CAPEX can be manipulated due to tax avoidance. Companies may try to optimize their tax liabilities by arranging acquisition of assets and expense amounts. Table 1 provides information about the variables.

As stated by Guiso & Parigi (1999), there are often measurement problems and issues of identification with the indirect indicators of uncertainty. We therefore used a direct measure of uncertainty, a news-based EPU index, to proxy for uncertainty. The advantages of this measure are that it is of high-frequency and has enough historical observations (Luk et al., 2018). In a globalized world, financial and economic variables may be affected not only by local EPU but also by major countries' EPUs. There are volatility spillovers among countries due to globalization, free trade, and technological advancements. Because of these reasons, we chose the GEPU (Global EPU) index developed by Davis (2016) as the main EPU indicator.

We took geometric averages of monthly values to construct the quarterly GEPU index. Figure 1 summarizes the main events that caused spikes in the GEPU index from 2005 Q1 to 2023 Q4. As observed, there is an increasing trend of EPU over time. The GEPU index takes its highest value in 2020 Q2, following the outbreak of COVID-19 that started in October. The governments were uncertain about how long they will continue lockdowns, which in turn influenced the parameters such as investment decisions, consumer demand, and job opportunities.

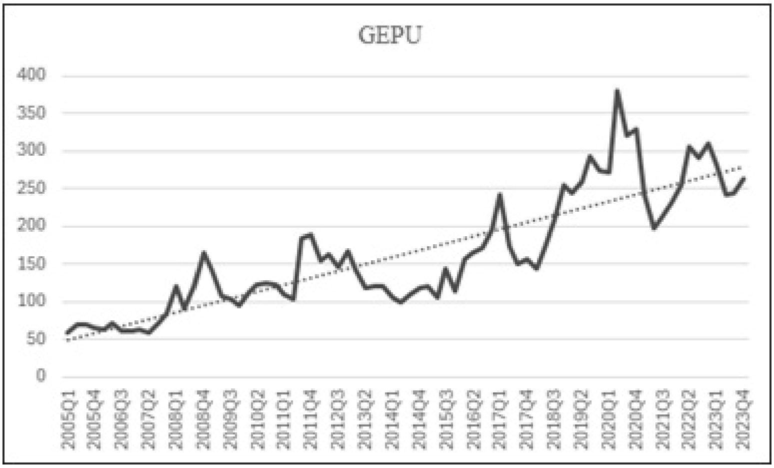

Figure 1: GEPU Index Spanning the Period from 2005 Q1 to 2023 Q4

Table 1: Variable Descriptions

Variable	Notation	Measure	Data Source
Dependent Variable			
Corporate Investment	*CI*	CAPEX / Total assets	Refinitiv
Independent Variable			
EPU Index Global	*GEPU*	Geometric mean of monthly Global PPP-adjusted EPU index	www.policyuncertainty.com
Control Variables			
Operating Cash Flow	*OCF*	(Revenue – Operating Expenses + Depreciation – Change in Working Capital) / total assets	Finnet
Tobin's Q	*TQ*	Market value / book value	Finnet
Gross Sales Growth	*SG*	[(Total sales in this period – total sales in the previous period) / total sales in the previous period] * 100	Finnet
Firm Size	*SIZE*	Natural logarithm of total assets	Finnet
GDP Growth	*GDP*	Real GDP growth rate (period on period)	OECD
Nominal Interest Rate	*IR*	Weighted Average Interest Rates Applied to Deposits Opened by Banks (%) (flow)	Central Bank of the Republic of Türkiye (CBRT)
Current Account Balance	*CAB*	Current account balance as a % of GDP (calendar and seasonally adjusted)	QECD

Descriptive Statistics

Table 2 depicts the descriptive statistics of the variables spanning the period from 2005 Q1 to 2023 Q4. Overall, the statistics indicate that none of the variables are normally distributed. Most of the variables exhibit positive skewness and have leptokurtic distribution. Specifically, the dependent variable CI has a mean value of 0.018 compared to a median value of 0.009, indicating that most of the investments are of lower risk whereas some investments are at high risk, skewing the mean upwards.

Table 2: Descriptive Statistics

Variable	Obs.	Mean	Median	Standard Deviation	Maximum	Minimum	Skewness	Kurtosis
CI	7,644	0.02	0.01	0.04	0.22	-0.03	9.64	144.46
GEPU	7,828	164.70	145.95	78.16	380.23	59.34	0.65	2.52
OCF	7,828	0.42	0.33	0.57	11.47	-0.60	5.39	69.42
TQ	7,828	1.70	1.23	2.15	61.70	0.35	11.64	230.98
SIZE	7,828	28.04	19.86	1.79	26.85	15.62	0.47	3.18
SG	7,828	37.30	15.77	111.99	3.63	-93.21	9.41	181.33
GDP	7,828	5.25	5.80	4.91	22.58	-12.93	-0.73	6.66
IR	7,828	13.67	12.04	5.79	41.65	6.15	1.75	8.54
CAB	7,828	-4.09	-4.41	2.52	2.76	-9.36	0.70	3.77

3.2. Econometric Model

To investigate the impact of EPU on CI decisions, we incorporate the GEPU index, firm-specific variables, and macroeconomic variables into the Q theory of the investment model. Panel data provides more opportunities to researchers as time series and cross-sectional data are included in the analysis simultaneously (Yerdelen-Tatoğlu, 2016). We used panel data and estimated the following fixed effects model's parameters:

$$CI_{i,t} = \alpha_i + \beta_1 GEPU_{i,t} + \beta_2 OCF_{i,t} + \beta_3 TQ_{i,t-1} + \beta_4 SIZE_{i,t} + \beta_5 SG_{i,t} + \beta_6 GDP_{i,t} + \beta_7 IR_{i,t} + \beta_8 CAB_{i,t} + \beta_9 QRT_t + \varepsilon_{i,t}, \quad (6)$$

where

α_i are firm fixed effects, ε_{it} are the independent and identically distributed idiosyncratic error term (i.i.d.), and QRT_t is a quarter dummy.

We also employed the fixed-effect quantile regression model developed by Machado & Santos Silva (2019), hereafter referred to as Method of Moments Quantile Regression (MM-QR), to predict the regression parameters. Quantile regression is more robust to outliers and more efficient than OLS when error terms are non-Gaussian (Koenker & Bassett, 1978). The MM-QR model specification is described as follows (Machado and Santos Silva, 2019: 8):

$$Y_{it} = \alpha_i + X'_{i,t}\beta + \left(\delta_i + Z'_{i,t}\gamma\right)U_{i,t}, \tag{7}$$

with $P\{\delta_i + Z'_{i,t}\gamma > 0\} = 1$. In this equation, Y_{it} is the dependent variable, and X indicates an m-dimensional vector of regressors, i.e., covariates. These regressors are used to explain the random variable Y's conditional quantiles, which follows a location-scale family distribution conditional on the m-vector of regressors X. Z is an m-vector including known differentiable transformations of X's components, and α_i and δ_i represent the individual i fixed effects (Machado & Santos Silva, 2019).

Equation 2 suggests the following (Machado and Santos Silva, 2019: 8):

$$Q_Y(\tau \mid X_{i,t}) = (\alpha_i + \delta_i q(\tau)) + X'_{i,t}\beta + Z'_{i,t}\gamma q(\tau), \tag{8}$$

where $\alpha_i(\tau) \equiv \alpha_i + \delta_i q(\tau)$. $\alpha_i(\tau)$ denotes individual i quantile-τ fixed effect. $Q_Y(\tau \mid X_{i,t})$ is the conditional quantile that shows the dependent variable's distribution, which is contingent on the distribution of the covariates, $X_{i,t}$.

In order to estimate $q(\tau)$ the following minimization problem should be solved (Machado and Santos Silva, 2019: 9):

$$\min_q \sum_i \sum_t \rho_\tau\left(\hat{R}_{i,t} - \left(\hat{\delta}_i + Z'_{i,t}\hat{\gamma}\right) q\right), \tag{9}$$

with check function satisfying the following condition: $\rho_\tau(B) = (\tau - 1)BI\,\{B \leq 0\} + \tau BI\{B > 0\}$ (Machado & Santos Silva, 2019: 9) where B denotes the residual term that is minimized.

The MM-QR method has some advantages over other quantile regression methods. First, it can incorporate individual effects that influence the entire distribution rather than simply shifting the location. More explicitly, while Koenker's estimator assumes that the fixed effects have an equal impact across all quantiles (Koenker, 2004), the MM-QR estimator, based on the method of moments, does not impose this restriction but instead assumes a model that accounts for both the location and scale of the distribution. The covariates have an impact on the Y's distribution solely through known location and scale functions (Machado & Santos Silva, 2019). Location parameters represent the conditional mean's parameters whereas scale parameters indicate whether all quantiles have the same slope. Second, this model is beneficial when individual effects and endogenous explanatory variables exist in the panel data models (Machado & Santos Silva, 2019). Third, the MM-QR approach demonstrates robust performance in various circumstances, remaining effective even in cases where the model exhibits nonlinearity (An et al., 2020).

4. Empirical Findings and Discussion

4.1. Multicollinearity Check

VIF Values

Multicollinearity exists when the independent variables of a regression are highly correlated. To assess whether there is a multicollinearity problem in the data, we use the variance inflation factor (VIF) criterion and report the correlation matrix for the independent variables. Table 3 presents the correlations between the variables as well as the VIF values. The average VIF value is 1.27. Since the correlations between the independent variables are less than the threshold value, i.e. 0.80, and since the VIF values are less than 5, it can be concluded that there is no significant multicollinearity among the regressors.

Table 3: Correlation Matrix and VIF Values

	GEPU	CAB	SIZE	IR	GDP	SG	TQ	OCF	VIF
GEPU	1								1.54
CAB	0.35	1							1.48
SIZE	0.41	0.14	1						1.29
IR	0.23	0.34	0.23	1					1.27
GDP	-0.23	-0.40	-0.01	-0.13	1				1.24
SG	0.28	-0.06	0.19	0.23	0.01	1			1.21
TQ	0.14	0.01	-0.07	0.10	0.11	0.08	1		1.10
OCF	0.06	-0.01	0.09	0.07	0.00	0.10	0.14	1	1.04

Autocorrelation, Heteroskedasticity, and Cross-Dependency Tests

In the presence of autocorrelation and heteroskedasticity, estimated coefficients may become biased and no longer efficient. We conduct tests to detect the presence of serial correlation and heteroskedasticity among the residuals of the regression equation. We use the modified Wald test for groupwise heteroscedasticity (Greene, 2002) in the fixed effects regression model. The results show that the null hypothesis of homoscedasticity of error variances is rejected at the 1% significance level, showing heteroscedasticity in the data.

In addition, we use the Bhargava et al. (1982) Durbin-Watson test to detect the existence of a first-order serial autocorrelation problem. The Bhargava et al. test statistic is less than the generally accepted critical value of 1.8 (Çınar, 2021), indicating the presence of a first-order serial autocorrelation problem in the data.

In panel data models, the error terms are assumed to be cross-sectionally independent, so we use Pesaran's (2004) cross-sectional dependence (CD) test to diagnose our data. The null hypothesis of the non-existence of cross-sectional dependency is rejected at the 1% significance level, meaning that there is cross-sectional dependency in the data. Table 4 displays diagnostic test results.

Table 4: Diagnostic Test Results

Test Statistics		
Modified Wald	**Bhargava et al. Durbin-Watson**	**Pesaran CD**
2.5×10^5***	1.25	13.72***

We also conduct normality tests, namely the Shapiro-Wilk (1965) and Jarque-Bera (1980) tests to evaluate whether the residual terms are normally distributed. Table 5 presents the results. The Shapiro-Wilk (1965) test statistic implies that the errors are not normally distributed as the null hypothesis of this test is rejected at the 1% significance level. The rejection of the null hypothesis of the Jarque-Bera (1980) test supports evidence of the non-normality of the error terms, too.

Table 5: Normality Test Results for the Error Terms

Tests	**Obs**	**W-Statistic**	**V(Chi-Square)**	**z-Score**	**Prob>z**
Shapiro Wilk-W	7,644	0.37	2,478.21	20.77	0.00
Jarque Bera		**chi^2**			**Prob>chi^2**
		6.5×10^6			0.00

Additionally, we present the quantile distribution graph of variable CI in Figure 2, along with the normality test results in Table 6. The overall findings indicate that the dependent variable, CI, is not normally distributed. All the performed tests, which test the null hypothesis of normality for the variable's distribution, reject this hypothesis at a 1% significance level. Furthermore, supporting this evidence, the variable series CI encompasses quantiles spanning from the 25^{th} percentile to the 75^{th} percentile.

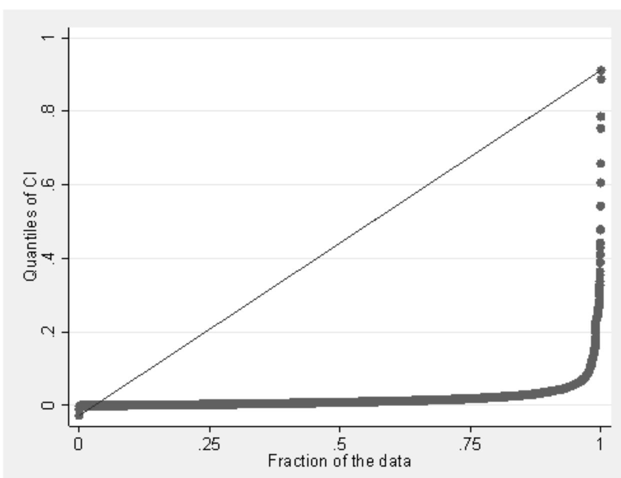

Figure 2: CI by Quantiles

Table 6: Normality Test Results for the CI

Tests	Obs	W-Statistic	V(Chi-Square)	z-Score	Prob>z
Shapiro Wilk-W	7,644	0.360	2,526.05	20.82	0.00
Jarque Bera		chi^2		Prob>chi^2	
		6.5×10^6		0.00	

4.2. Regression Results

Diagnostic test results supply evidence on behalf of the existence of heteroskedasticity, autocorrelation and cross-dependency problems. To mitigate these problems in the data, we use the Driscoll-Kraay (1998) nonparametric covariance estimator to calculate the standard errors. This estimator is "robust to general forms of cross-sectional and temporal dependence" (Hoechle, 2007: 283). Moreover, standard errors are heteroscedasticity – and autocorrelation-consistent with this estimator (Hoechle, 2007). We estimate the regression parameters using fixed effects model with Driscoll-Kraay standard errors. Additionally, considering the distribution of CI in different quantiles in conjunction with the non-normality of the error terms, we use quantile regression as an alternative estimation technique. Machado & Santos Silva (2019) state that if distributions are not symmetric, MM-QR with Jackknife Bias Correction produces better results. Since our data is not symmetric, we estimate parameters using MM-QR with Jackknife Bias Correction. Table 7 shows the overall regression results.

Table 7: Baseline Regression Results

Variables	FE Model with Driscoll-Kraay Standard Errors	MM-QR Model with Jackknife Bias Correction		
		25th Quant	50th Quant	75th Quant
GEPU	-0.00003***	-0.00002**	-0.00002**	-0.00002*
	(0.00001)	(6.90e-06)	(0.00001)	(0.00002)
OCF	0.0031*	0.00030	0.00303	0.00315
	(0.00158)	(0.00244)	(0.0028)	(0.00378)
TQ	0.00079**	0.00015	0.00045	0.00106
	(0.00039)	(0.00024)	(0.00038)	(0.00080)
SIZE	0.00428***	0.00322*	0.00372*	0.00473*
	(0.00114)	(0.00165)	(0.00193)	(0.00260)
SG	0.00002***	2.91e-07	7.32e-06**	0.00002***
	(4.25e-06)	(3.44e-06)	(3.48e-06)	(7.09e-06)
GDP	-0.00024**	-0.00009	-0.00016	-0.00030**
	(0.00010)	(0.00009)	(0.00011)	(0.00015)
IR	-0.00008	-0.00012	-0.00010	-0.00006
	(0.00010)	(0.00015)	(0.00013)	(0.00016)
CAB	-0.00029	-0.00014*	-0.00021**	-0.00035
	(0.00020)	(0.00008)	(0.00010)	(0.00025)
Quarter Dummy	Yes	Yes	Yes	Yes
Constant	-0.06733***			
	(0.02073)			
R-squared	0.0294			

*Note: *, ** and *** indicate significance levels at 10%, 5% and 1%, respectively. Numbers in parentheses are the standard errors.*

According to the results of the FE Model with Driscoll-Kraay Standard Errors, the coefficient of the GEPU is significantly negative at the 1% level, resulting in the failure to reject the H_1. This result aligns with the real options theory on the irreversibility and forward-looking nature of investments. Bertola (1988) posited that investments usually happen in good states when future marginal revenue product is anticipated to be high. If a bad state occurs, such as when firms face a common positive shock (Gulen & Ion, 2016), due to the high fixed costs, the firms that have more irreversible investment projects have a tendency to disinvest or postpone their investments. Irreversibility of investments and uncertainty increase the value of waiting. As new information that decreases uncertainty arrives on the market with time, firms can make better decisions to invest. But, waiting for new information increases the critical investment threshold, subsequently increasing the required project value. Therefore, the impact of uncertainty on investment becomes negative. The results with the MM-QR with Jackknife Bias Correction model also indicate a negative significant impact of GEPU on CI at all quantiles albeit the coefficient of GEPU is significant only at 10% in the 75th quantile. The empirical results of this study support the empirical findings in the literature (Gulen & Ion, 2016; Ramesh, 2024; Wang et al., 2014).

Regarding the control variables, while interpreting the coefficients, we primarily use the results of the FE Model with Driscoll-Kraay Standard Errors. As shown in Table 7, Tobin's Q ratio is positive at the 5% significance level, as the theory predicts. The analysis result confirms that Tobin's Q reveals a positive and significant impact on fixed asset investments. As the management tries to maximize the present net worth of the firm, firms choose to invest in projects that yield positive NPV and increase the market value of shares. This ratio is commonly used as a proxy for firm value in the literature. Its association with current asset investments and financing policy of firms can also be investigated (Karaca et al., 2025; Karaca, 2023; Martinez-Sola et al., 2012).

In the extant literature of financing, cash flow is often used as a capital constraint variable. Especially risky investments depend on the availability of internal funds on hand when there is not enough external financing, assuming that capital markets are incomplete. Including cash flow as a variable in this model means accepting the reality that firms may face capital constraints. The regression results indicate that the coefficient of OCF is positive and significant at the 10% level, indicating that CI is sensitive to internal cash flows. That is, in case of limited access to external cash flows, internal cash flows are used for financing investments. The coefficient of SIZE is positive at the 1% significance level, which indicates that larger firms invest more than smaller firms do. As Ghosal & Loungani (2000) stated, firm size can be a proxy for capital market access. The results also show that there is a positive and significant relationship between CI and SG at the 1% significance level. An increase in sales is associated with an increase in profitability, which in turn can be used for investment financing if the profits are retained in the company.

The impact of the GDP on CI is negative and significant at the 5% significance level; however, it is not of the expected sign. The other two macroeconomic variables, namely IR and CAB have the expected signs although none of them have any statistical significance based on the FE Model with Driscoll-Kraay Standard Errors. On the other hand, based on the results of the MM-QR with Jackknife Bias

Correction model, CAB's impact is negative and significant at the 25th and 50th quantiles, indicating that the negative impact of CAB is higher for low level of investment.

4.3. Controlling for Endogeneity

We examine whether EPU has an impact on CI levels; however, it is important to note that investment decisions by firms can also influence EPU. To control endogeneity, we use the two-stage least squares (2SLS) method. We treat the current level of GEPU as the endogenous variable and employ the two-lagged EPUS as the instrumental variable. Table 8 presents the results. The findings are consistent with the findings of the baseline regressions, indicating a negative and significant association between GEPU and CI at the 1% significance level.

Table 8: 2SLS Estimation Results

Variables	Model
GEPU	-0.00003***
	(0.00001)
OCF	0.00580***
	(0.00093)
TQ	0.00091***
	(0.00023)
SIZE	0.00225***
	(0.00032)
SG	0.00002***
	(5.21e-06)
GDP	-0.00022**
	(0.00011)
IR	-5.74e-06
	(0.00009)
CAB	-0.00014
	(0.00024)
Constant	-0.02857***
	(0.00578)
Quarter Dummy	Yes
Number of obs.	7,452
R-squared	0.04001

*Notes: *, **, and *** denote significance at the 10%, 5% or 1% level, respectively. Numbers in parentheses are the standard errors.*

4.4. Using Alternative EPU Indices

Beckmann et al. (2023) find that the US, Eurozone, UK, and China are the main sources of uncertainty affecting other countries. Regarding the trade relationship between Russia and Türkiye and due to their geographical proximity, Russian EPU index may also be a potential source of uncertainty that may affect Turkish CI. We use the main global economies' monthly EPU indices, namely the European EPU index (EPUE), the US EPU index (EPUS), the Russian EPU index (EPUR) all of which are developed by Baker et al. (2016), and the Chinese EPU Index (EPUC) developed by Baker et al. (2013). We take the geometric mean of each monthly EPU index and create a quarterly series for the period from 2005 Q1 to 2023 Q4. Table 9 displays the fixed effects estimation results with Driscoll-Kraay standard errors using alternative EPU indices. As the results show, there is a strong and negative relationship between EPUs of US and China and the CI level in Türkiye.

Table 9: Regression results with Alternative EPU Indices

	Model I	Model II	Model III	Model IV
EPUE	-2.89e-06			
	(0.00001)			
EPUS		-0.00003***		
		(8.61e-06)		
EPUC			-8.44e-06**	
			(3.55e-06)	
EPUR				-5.23e-06
				(6.09e-06)
OCF	0.00268	0.00283*	0.00302*	0.00279*
	(0.00164)	(0.00155)	(0.00156)	(0.00157)
TQ	0.00064*	0.00079**	0.00072*	0.00068*
	(0.00038)	(0.00039)	(0.00038)	(0.00036)
SIZE	0.00242*	0.00351***	0.00375***	0.00288**
	(0.00133)	(0.00094)	(0.00106)	(0.00114)
SG	0.00001***	0.00001***	0.00002***	0.00001***
	(4.68e-06)	(4.36e-06)	(4.34e-06)	(4.72e-06)
GDP	-0.00014	-0.00027***	-0.00020*	0.00015*
	(0.00011)	(0.00010)	(0.00011)	(0.00009)
IR	-8.79e-07	-0.00014	-7.19e-06	8.06e-07
	(0.00012)	(0.00010)	(0.00009)	(0.00010)
CAB	-0.00043*	-0.00042**	-0.00020	-0.00045*
	(0.00025)	0.00020	(0.00024)	(0.00024)
Quarter Dummy	Yes	Yes	Yes	Yes
Constant	-0.03669	-0.05176***	-0.06017***	-0.04535**
	(0.02392)	(0.01749)	(0.01979)	(0.02128)
Number of obs.	7,644	7,644	7,644	7,644
Number of firms	103	103	103	103
R-squared	0.0272	0.0296	0.0287	0.0274

*Notes: *, **, and *** denote significance at the 10%, 5% or 1% level, respectively. Numbers in parentheses are the standard errors.*

4.5. Impact of EPU over Time

Previous literature (Malkiel et al., 1978; Nickel, 1977) has shown that the impact of uncertainty on CI may occur over time instead of all at once (that is, it spreads over future time periods). Therefore, we employ a finite, distributed-lag model and examine the long-term impact of EPU. We calculate the joint significance and long-run coefficient of lags of GEPU using quarterly horizons, allowing us to examine the long-term impact of GEPU on CI decisions. To do this, we regress the lags of the GEPU index from 0 to 5, from 0 to 9, and later from 0 to 10 on CI and calculate their joint significance. We use the following equation:

$$CI_{i,t} = \alpha_i + \sum_{h=0}^{H} \gamma_h GEPU_{i,t-h} + \beta_1 OCF_{i,t} + \beta_2 TQ_{i,t-1} + \beta_3 SIZE_{i,t} + \beta_4 SG_{i,t} + \beta_5 GDP_{i,t} + \beta_6 IR_{i,t} + \beta_7 CAB_{i,t} + \beta_8 QRT_t + \varepsilon_{i,t}, \quad (10)$$

where, α_i represents the individual fixed effects, γ and β indicate the slope coefficients, and ε_{it} denotes the i.i.d. idiosyncratic error term. $GEPU_{i,t-h}$ is the GEPU index $(h \in \{0, 1, 2, \ldots\ldots 10\})$, where h corresponds to the lag between the CI and the GEPU index.

Table 10 presents the results of the regressions using the fixed effects model with Driscoll-Kraay standard errors. The regression results indicate that the impact of GEPU on CI decisions is statistically significant at all lags up to 10. The joint significance of these lags illustrates that GEPU causes significant and persistent fluctuations in long-term CI. Additionally, this result indicates that the impact of EPU on CI decisions spreads over time.

Next, we test the sign of this significant relationship by calculating the long-run cumulative effect of GEPU on CI decisions, using the finite distributive lag model. This computation indicates how much CI finally changes in relation to a permanent change in the GEPU index. The sum of the coefficients of the lags of GEPU (i.e., the long-run multiplier) from 0 to 5 and up to 9 lags are all significant and negative at the 1% significance level. The significance of the long-run multiplier disappears at the 10^{th} lag in accordance with the real options theory. Based on these results, we reject H_2, implying that firms do not become risk-loving under uncertainty in the long-term. Uncertainty does not increase the flexibility of the embedded options within the investment project in the long-run; option value of abandoning or delaying investment has a greater value than early investing (Trigeorgis, 2002). Additionally, most of the investments cannot be postponed indefinitely because the value of cash flows given up outweighs the value gained by waiting for new information that resolves uncertainty (Gulen & Ion, 2016: 551).

Table 10: Long-Term Fixed Effect Estimation Results

	Model I	Model II	Model III	Model IV
L1.GEPU	0.00003***			
	(0.00001)			
GEPU, lags 0 to 5, F statistic		4.02***		
Long-run multiplier, lags 0 to 5		-0.00005***		
		(0.00001)		
GEPU, lags 0 to 9, F statistic			3.94***	
Long-run multiplier, lags 0 to 9			-0.00003**	
			(0.00002)	

GEPU, lags 0 to 10, F statistic				6.62***
Long-run multiplier, lags 0 to 10				-0.00002
				(0.00002)
OCF	0.00294*	0.00277*	0.00224	0.00185
	(0.00157)	(0.00157)	(0.00157)	(0.00154)
TQ	0.00079**	0.00088**	0.00085**	0.00081**
	(0.00039)	(0.00043)	(0.00041)	(0.00039)
SIZE	0.00434***	0.00528***	0.00444***	0.00345**
	(0.00116)	(0.00127)	(0.00140)	(0.00142)
SG	0.00002***	0.00002***	0.00001*	0.00001
	(4.16e-06)	(4.60e-06)	((6.25e-06)	(6.37e-06)
GDP	-0.00021**	-0.00011	-0.00017	-0.00020*
	(0.00009)	(0.00010)	(0.00011)	(0.00011)
IR	-0.00011***	-0.00011	-0.00007	-0.00006
	(0.00009)	(0.00008)	(0.00009)	(0.00010)
CAB	-0.00026	-0.00018	-0.00028	-0.00033
	(0.00022)	(0.00021)	(0.00025)	(0.00026)
Constant	-0.06853***	-0.08482***	-0.07028***	-0.05234**
	(0.02131)	(0.02338)	(0.02518)	(0.02496)
Number of Obs.	7,748	7,159	6,775	6,675
Number of Firms	103	103	103	103
Quarter Dummy	Yes	Yes	Yes	Yes
R-squared	0.0308	0.0328	0.0339	0.0360

*Notes: *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. The numbers in parentheses are the standard errors. We used fixed effects model with Driscol-Kraay standard errors.*

5. Conclusion and Discussion

In this study, we examine the impact of EPU on the CI decisions of 103 Turkish manufacturing firms listed on BIST spanning the period from 2005 Q1 to 2023 Q4. Our investigation of the impact of EPU on CI decisions is guided by the real options theory, which predicts that firms with more irreversible investments have a tendency to delay investments when market conditions worsen because the sunk costs make it too costly to undo an investment. Real options give investors an alternative to invest now or after uncertainty is resolved.

We evaluate short – and long-term results of EPU on CI decisions. Empirical results indicate a negative and significant impact of EPU on CI decisions in the short-term in alignment with the real options theory's predictions. We also measure the long-term impact of EPU on CI. Results indicate that the impact of EPU on CI is significantly negative, persistent and prolonged, which supports the findings of Chen et al. (2020). Empirical results also indicate that global uncertainties influence capital allocations of firms in a local country as in line with the findings of Vo and Nguyen (2023).

Regarding the control variables, firm-level variables have the expected signs: OCF, TQ, SIZE, and SG positively affect CI. Regarding the macroeconomic variables, while GDP has the opposite of the expected sign, IR and CAB's impacts are insignificant based on the results of the FE model with Driscoll-Kraay standard errors.

Our findings have some major implications. First, a good investment climate can be realized by decreasing the EPU. In this matter, governments should implement economic policies that are foreseeable and that do not create uncertainty. Besides, institutions should be strengthened because this prevents changing decisions, which may create uncertainty as well. Second, EPU can have persistent and prolonged effects that create fluctuations in CI, which is important for emerging economies, such as Türkiye, wherein fixed investments have a major influence on economic growth. Third, companies should also consider global EPU besides the local one while making projections about their corporate investment decisions. Finally, companies should consider the negative impact of uncertainty, which necessitates risk management. They can diversify the sectors they operate in and their products. They can operate in different countries, too.

Author Contribution

CONTRIBUTION RATE	EXPLANATION	CONTRIBUTORS
Idea or Notion	Forming the research idea or hypothesis	Güneş Topçu
Literature Review	Reviewing the literature required for the study	Güneş Topçu
Research Design	Designing method, scale, and pattern for the study	Güneş Topçu & Jale Oran
Data Collection and Processing	Collecting, organizing, and reporting data	Güneş Topçu
Discussion and Interpretation	Taking responsibility in evaluating and finalizing the findings	Güneş Topçu & Jale Oran

Conflict of Interest

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