

# Research on the Impact of Trade Policy Uncertainty on the Digital Transformation of Chinese Export Firms

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## Abstract

This paper uses data from listed companies in China from 2007 to 2022 to prove that the increase in trade policy uncertainty has promoted the digital transformation process of Chinese export firms. Through theoretical analysis and empirical testing, we found that the promotion effect of trade policy uncertainty on the digital transformation of Chinese export firms is related to trade costs. Rising trade policy uncertainty has increased trade costs, which in turn has forced Chinese exporters to accelerate their digital transformation. Digital capabilities are used to resolve cost challenges brought about by trade policy uncertainty. In addition, this paper also finds that when trade policy uncertainty promotes the digital transformation of Chinese exporters, foreign investment will significantly strengthen this role, while financing constraints will weaken this role, reflecting the importance of foreign investment. Finally, we found that the increase in trade policy uncertainty reduces the imbalance of digital development levels in industries and regions, promotes the digital transformation of industries and regions with lower digitalization levels, and is conducive to promoting the balanced development of digitalization in industries and regions in a country.

**Keywords:** trade policy uncertainty, digital transformation, Chinese export firms.

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## 1. Introduction

In recent years, with the progress and development of digital technology and the digital economy, China has paid more and more attention to the application of digital technology and the advancement of digital transformation. The 20th National Congress of China held in 2022 emphasized the need to promote the opening up to the outside world, enhance China's level of trade and investment cooperation, promote the optimization and upgrading of trade in goods and services, accelerate the development of digital trade and the construction of a strong trading nation, and deeply participate in global industrial division of labor and cooperation. From a micro point of view, the specific behavior of developing digital trade and building a major trading country is to promote the digital development of China's export enterprises. The development of the export economy is an important driving force for China's economic growth. Data released in 2022 showed that China's trade in goods increased by 7.7%, trade in services increased by 12.9%, and the net export of goods and services contributed 17.1% to China's GDP. Digital trade will occupy the main body of future trade development. In 2022, China's digital service trade accounted for 42% of total service trade. It is predicted that the proportion of global digital service trade will reach 75% by 2030. Promoting the digital transformation of export firms will form new advantages for future trade development, inject new impetus into economic development, and thereby promote the development of a country's digital trade and the construction of a digital power.

In fact, the digital transformation of export firms is a trend to adapt to the new digital era and achieve new digital development. The Internet has a huge impact on the trade of export firms. The increase in Internet penetration can significantly increase the quantity and quality of corporate exports. The Internet will also increase the probability of corporate exports (Zhang & Liu, 2023). The application of the Internet is an important part of digital transformation. Export firms undergoing digital transformation can expand production and improve business through the Internet, thereby improving international competitiveness (Kraus et al., 2022). China actively promotes the planning and construction of a digital economy and digital society. For example, China issued the "National Institutional Reform Plan" to promote the construction of basic data systems and the integration, development, and sharing of data resources.

At the same time, the uncertainty of trade policy has further promoted the digital transformation of Chinese exporters. China's trade policy uncertainty has fluctuated frequently, and the uncertainty has continued to rise and is at a relatively high level. For example, emergencies such as the outbreak of the Russia-Ukraine war and the continued spread of COVID-19 have intensified the turbulence of the world economy and trade frictions between countries (Wang et al., 2021), and the external uncertainty faced by China has intensified. On the other hand, China itself faces the task of reform, development, and stability, and its internal environment is in an atmosphere of change. For example, it has proposed new concepts of focusing on the domestic cycle and coordinated development of international and domestic dual cycles, as well as reasonable reductions of the negative list and other policy measures. The rise in trade policy uncertainty has intensified exchange rate and price fluctuations, triggering an increase in trade costs. The increase in

transportation and other transaction costs has also increased trade costs. The increase in trade costs has further pushed export firms to accelerate digital transformation and respond to the cost crisis caused by uncertainty in trade policies through digital innovation.

In order to explore the impact of trade policy uncertainty on the digital transformation of export enterprises, this paper empirically studies the impact of trade policy uncertainty on the digital transformation of Chinese export enterprises and its impact mechanism, with a sample size of 22,797.

The rest of this paper is organized as follows. Section 2 introduces the literature review. Section 3 is the theoretical analysis and puts forward hypotheses. Section 4 is about the empirical tests, including model design, variable definition, result analysis, and robustness tests. The last section gives the conclusions and implications of this paper.

## **2. Literature review**

This paper is closely related to the literature on digital transformation and trade policy uncertainty. On the one hand, with the development of digital technology, existing literature has gradually paid attention to the research on digital transformation, and the research conducted about the digital transformation from the influencing factors, industries, and heterogeneous firms. There is widespread recognition that digital technologies and executive perceptions will have a huge impact on digital transformation. Digital technology has created the need to manage the workforce with digital capabilities. In order to meet the current workforce management needs, ensure that digital transformation is put on the agenda (Akter et al., 2023). Staka et al. (2022) also believe that technological innovation is a key link in digital transformation. In addition, the complexity and centrality of executives' cognition can promote the digital transformation of firms, and digital policies will further strengthen this effect (Zhu et al., 2022). From an industry perspective, digital business transformation is an industry-wide trend. Firms use digital technology to transform existing businesses. This is obviously a disruption to the industry, but it is not a crisis. Industries undergoing digital transformation can increase their market share rather than suffer market failure (Miklosik et al., 2023; Mutlu et al., 2022). As far as firms are concerned, in the face of digital transformation trends, small and medium-sized firms need to evaluate the technologies they own and invest in skill upgrades and employee capabilities according to their own circumstances, rather than completely imitating others due to external pressures (Omrani et al., 2022). Liu et al. (2023) focused on the digital transformation of state-owned firms and found that the participation of non-state-owned shareholders will accelerate the digital transformation process of state-owned firms. Trading firms further improve digital technology through digital transformation, thus forming new value for the firms (Ianenko et al., 2020). Service export firms with a higher level of digitalization have a greater impact on global economic exports. Improving the digital services trade level of export firms can effectively improve digital services exports (Jiang & Jia, 2022).

In short, digital transformation has become a key strategy for firms to enhance resilience, effectively respond to external shocks, and achieve sustainable development (Wang & Chen, 2022).

On the other hand, the existing literature examines the impact of trade policy uncertainty on micro-level firm behavior or performance. Rising trade policy uncertainty in recent years has increased macro-environmental risks, brought new challenges to the economy, and changed the behavioral decisions of micro-firms. Trade policy uncertainty reduces the liquidity of stocks, increases stock price risk, and passes this risk on to banks. Banks' passive risk-taking increases and their willingness to take active risk-taking decreases (Hu et al., 2024). The increase in trade policy uncertainty will also lead to increased financial constraints and operational risks for firms (Wang et al., 2021). The trade restrictive policies that have been imposed on China in the past few years have caused damage to the economy. In particular, clothing, machinery, and other manufacturing industries have been hardest hit by trade policy uncertainty (Wang & Wu, 2023). The high degree of uncertainty in trade policy will also significantly inhibit the extensive and intensive profitability of firms' exports (Zhou & Wen, 2022), which poses challenges to the daily operations of export firms. Faced with the impact of trade policy uncertainty, firms mainly respond by changing their entry and exit decisions. The decrease in trade policy uncertainty will increase the market transformation decisions of firms, that is, it will increase the decisions of domestic firms to shift to foreign export markets (Liu et al., 2023). Crowley et al. (2018) also believe that when trade policy uncertainty increases, the probability of Chinese firms entering foreign markets will decrease.

Existing research on trade policy uncertainty and research on digital transformation have become hot topics, and scholars have conducted in-depth research from both the macro and micro perspectives. In the micro-level export enterprise-level research that is closely related to this paper, the existing literature pays attention to the impact of trade policy uncertainty on export firms' trade, product quality, market entry and exit decisions, etc. However, there are few studies on the impact of trade policy uncertainty on the digital transformation decisions of export firms. At the same time, existing research on the digital transformation of export firms mainly focuses on the economic effects of the digital transformation of export firms, such as enhancing corporate resilience. There is still relatively little research attention on the factors affecting the digital transformation of export firms. This paper studies the digital transformation of China's export firms with trade policy uncertainty and proposes a digital strategy to deal with the impact of uncertainty under the risks and challenges brought on by trade policy uncertainties, which provides a new perspective for the study of the impact of trade policy uncertainty on micro export firms. In addition, this paper focuses on the digital transformation of export firms. From the perspective of export firms, it explores the role and mechanism of using digital transformation strategies to resolve the impact of trade policy uncertainty, and supplements the research on response measures to the impact of trade policy uncertainty.

### 3. Mechanisms

#### 3.1 Trade cost channel

Trade policy uncertainty increases transaction costs and risks. Transaction cost theory believes that uncertainty is one of the sources of transaction costs. Uncertainty in the environment increases costs, such as negotiation and contract signing, during the transaction process. According to the Escape from Competition effect, firms hope to escape fierce competition and obtain profits through innovation. Digital transformation is the process of deep integration of firms with digital technology, breaking or changing old production methods to form new production combinations (Fan, 2021). From this definition, digital transformation embodies an innovation in the digital economy era. Through digital transformation, export firms can get out of the original competitive environment and obtain more profits. From a risk perspective, according to the Risk Preference Theory, risk preferences are more willing to choose high-risk and high-return investment projects. Digital transformation itself has its risks. The increase in trade policy uncertainty further exacerbates the environmental risks, and exporters with larger market size and productivity have a higher risk tolerance and are more likely to actively engage in digital transformation as risk appetites increase.

Transaction costs are an important component of trade costs; uncertainty not only increases transaction costs but also increases trade costs. For example, increased uncertainty in U.S. trade policy will increase the prices of some important imported products (Yu et al., 2023) and uncertainty in commodity prices will increase the cost of bank loans (Bermpei et al., 2023). Economic policy uncertainty will lead to a significant increase in capital costs and debt financing costs (Liu & Wang, 2022), and rising monetary policy uncertainty will also increase debt financing costs (Xiang & Li, 2022). Specific events that lead to increased trade policy uncertainty, such as the Sino-US trade friction, have an impact on the prices of consumer goods and investment goods in the tradable sector, as well as intermediate import costs through tariff shocks (Yang et al., 2023). When rising trade policy uncertainty increases current or future trade costs, export firms will reduce costs and increase efficiency through digital transformation. Digital transformation integrates digital technology and establishes and improves online communication channels to facilitate communication and simplify transaction links, thereby reducing the overall trade costs of export firms. Through digital transformation, firms can obtain information on products and customers more quickly, and can also transmit information to the outside world through the Internet, reducing the degree of information asymmetry between the two parties (Zhao et al., 2023). Digital transformation can also speed up the firm's response to the long-tail needs of its customers and improve the firm's overall operational efficiency (Peng & Tao, 2022). At the same time, existing research has found that digital strategy is the optimal strategy to deal with trade policy uncertainty, and the rise in economic policy uncertainty will significantly promote the level of digital transformation of firms (Zhu et al., 2023; Yang et al., 2023). As an important component of economic policy uncertainty, trade policy uncertainty will play an important role in promoting the digital transformation of export firms. Therefore, this paper proposes hypothesis 1 and 2:

**Hypothesis 1:** *All other things being equal, trade policy uncertainty will have a positive impact on the digital transformation of exporting firms.*

**Hypothesis 2:** *Rising uncertainty over trade policies has increased trade costs, forcing exporters to accelerate their digital transformation.*

### **3.2 Foreign investment and financing constraints channels**

When trade policy uncertainty positively affects the digital transformation of export firms, foreign investment will strengthen this promoting effect, while financing constraints will weaken this positive impact. Attracting foreign investment is an effective way for firms to introduce advanced technologies (Liu & Wang, 2003). The technological spillover effect of foreign investment helps export firms achieve technological progress, which in turn can accelerate the digital transformation process of export firms. Foreign investment is also one of the important factors in improving the total factor productivity of firms (Hiep et al., 2022). The increase in total factor productivity of export firms reflects the optimization of resource allocation and the improvement of organizational management levels, and directly or indirectly promotes digital transformation. At the same time, foreign investment can promote firms' innovation and improve the quantity and quality of innovation (Chen et al., 2022). While innovation establishes new production functions, it promotes the deep integration of digital technology with physical firms, thereby improving the level of digital transformation of export firms. Developing an export-oriented economy and attracting foreign investment can help countries that lack domestic capital reserves and technological development achieve industrial structure upgrades and economic growth (Liu et al., 2023). Similarly, for export firms, the introduction of investment can improve their capital reserves and technical level, thereby achieving digital transformation, upgrading, and obtaining more profits. However, financing constraints will weaken the positive impact of trade policy uncertainty on the digital transformation of export firms. Financing constraints tend to inhibit firms' R&D investment and innovation (Li et al., 2023). Financing friction affects firms' investment decisions. The increase in financing constraints makes firms financially restricted, distorts firms' inter-temporal decisions, and makes them biased to choose projects with short-term benefits or cost savings (Caggese et al., 2019). Digital transformation achieves more effective resource allocation through digital technology. It involves innovations in management models and business operations, including firms' software upgrades and improvements to workers' learning abilities (Dou et al., 2023). This process is very long, and it requires continuous capital investment. The short-term investment decision-making preference of export firms caused by financing constraints is not conducive to digital transformation and hinders the digital transformation development of export firms. Therefore, this paper proposes hypothesis 3.

**Hypothesis 3:** *When trade policy uncertainty has a positive impact on the digital transformation of export firms, foreign investment will strengthen this promoting effect, while financing constraints will weaken this positive effect.*

## 4. Main variables

### 4.1 Dependent variable: Digital transformation of export firms

The dependent variable of this paper is the digital transformation of Chinese export firms (InEDT), which is expressed by summing up the frequency of words such as artificial intelligence and big data and taking the logarithm (Wu et al., 2021). In this article, an export enterprise is defined according to whether the business scope of the enterprise includes export business; that is, an enterprise whose business scope includes "export" is defined as an export enterprise. Digital transformation word frequency data and firm business data come from the China Stock Market & Accounting Research (CSMAR) database. In the following paper, the data on digital transformation is also directly used for robustness testing using data constructed by Wu Fei of Guangdong University of Finance and others.

### 4.2 Independent variable: trade policy uncertainty

According to previous research (Kang et al., 2014), the most commonly used trade policy uncertainty index data comes from the policy uncertainty website, which uses text construction methods to include the most representative newspapers and magazines in each country. The monthly trade policy uncertainty index is calculated based on statistical calculations of word frequency data such as "uncertainty," "trade policy," and "economy." The China monthly trade policy uncertainty index data used in this paper comes from this website, and the monthly data are summed to the annual level through the arithmetic mean and divided by 100 to obtain China's trade policy uncertainty (TPU).

### 4.3 Controlling variables

According to previous research (Li et al., 2022; Zhu et al., 2023; Wang et al., 2021), we added a set of control variables as follows: (1) GDP growth rate (GDPZ) is used to reflect the economic development status of the country. (2) The monetary supply growth rate (MZ) is used to reflect the easing degree of a country's monetary supply policy. (3) Price changes (BP) are expressed by the fixed asset investment price index. (4) Management level (Manage) is expressed by dividing administrative expenses by operating income. (5) Firm size (Size) is expressed by taking the logarithm of the number of the firm's employees. (6) Two positions in one (Yb) refer to whether the chairman and the general manager are the same person; if it's the same person, it's assigned a value of 1, and in other cases, it's 0. (7) Audit opinion (Auppt), the disclosed audit opinion reflects the firm's operating conditions. If the disclosed audit opinion is standard and unreserved, it is set to 1, and the rest is set to 0. (8) The equity concentration ratio (Shrcr) is expressed by the shareholding ratio of the firm's largest shareholder. (9) TobinQ value (TobinQ) is expressed as a company's market capitalization divided by total assets and can reflect a company's potential growth capacity. (10) Return on total assets (Zroa), expressed as net profit divided by total assets, can reflect the firm's profitability. (11) Fixed asset investment ratio (Fixa), expressed by dividing the firm's net fixed assets by total assets. The above data are all from CSMAR and the National Bureau of Statistics of China.

This paper first selects the data of all A-share and B-share listed firms from 2007 to 2022, and drops: (1) firms in the financial industry; (2) firms that are delisted or at risk of delisting (\*ST). In order to avoid the interference caused by outliers, this paper performs a 1% two-sided tailing treatment for non-dummy variables at the enterprise level. Finally, the total data used In the empirical study includes 22,797 observations.

#### 4.4 Descriptive statistics

Table 1 presents descriptive statistics. The maximum, minimum, and average values of digital transformation of Chinese export firms are 4.97, 0 and 1.087, respectively, indicating that the levels of digital transformation of different export firms vary greatly, and some export firms have not even carried out digital transformation. The maximum value of trade policy uncertainty is 6.876, the minimum value is 0.107, and the average value is 2.454, which shows that the changes in China's TPU have been relatively large in recent years. The data for the control variables is also within a reasonable range. For example, the mean value of concentrated ownership is 33.66, indicating that the ownership is relatively concentrated. Two positions in one and audit opinions are two dummy variables, including 0 and 1. The values of the return on total assets and the average value of the fixed asset investment proportion are both between 0 and 1.

**Table 1: Descriptive statistics of main variables**

Variables	N	Mean	SD	Min	Max
<b>lnEDT</b>	22797	1.087	1.388	0	4.970
<b>TPU</b>	22797	2.454	2.009	0.107	6.876
<b>GDPZ</b>	22797	7.001	2.570	2.200	14.200
<b>MZ</b>	22797	0.124	0.043	0.082	0.276
<b>BP</b>	22797	1.028	0.027	0.976	1.089
<b>Manage</b>	22797	0.089	0.075	0.007	0.487
<b>Size</b>	22797	7.590	1.216	4.477	10.970
<b>Yb</b>	22797	0.291	0.454	0	1
<b>Auppt</b>	22797	0.962	0.190	0	1
<b>Shrcr</b>	22797	33.660	14.720	8.646	73.820
<b>TobinQ</b>	22797	2.069	1.302	0.871	8.587
<b>Zroa</b>	22797	0.035	0.069	-0.310	0.201
<b>Fixa</b>	22797	0.208	0.144	0.003	0.635

## 5. Methodology

In this paper, we use the following panel econometric model to examine the impact of trade policy uncertainty on the digital transformation of Chinese export firms:

$$\ln EDT_{iqt} = \beta_0 + \beta_1 TPU_t + \sum \beta_i control_{iqt} + \delta_i + \varepsilon_{iqt} \quad (1)$$

In formula (1), the subscripts *i*, *q* and *t* represent the export firm, province and time.  $\ln EDT_{iqt}$  is the dependent variable digital transformation of Chinese exports and takes the logarithm.  $TPU_t$  is the independent variable trade policy uncertainty.



$control_{iqt}$  is the controlling variables, including GDP growth rate, monetary supply growth rate, price fluctuations, management level, firm size, two positions in one, audit opinions, ownership concentration, Tobin's Q value, total asset return rate, and fixed asset investment proportion.  $\delta_i$  is the firm's fixed effect, used to control influencing factors at the firm level that do not change with time, such as the export firm's culture. This paper does not control for time-fixed effects. This is because the trade policy uncertainty used in this paper is year-level data, and controlling time-fixed effects will cause multicollinearity problems. Region-level controlling variables are added to eliminate influencing factors that do not change with the export firms at the time level, and alleviate the bias caused by the absence of controlling for the time-fixed effect on the regression results.  $\varepsilon_{iqt}$  is the random error term. This paper uses robust standard errors clustered at the firm level.

## 6. Empirical results

### 6.1 Baseline regression

The following paper tests Hypothesis 1: TPU has a positive impact on the digital transformation of Chinese export firms. Table 2 shows the empirical results of formula (1). Column (1) performs the regression on the dependent and independent variables. Column (2) only adds the controlling variables. Column (3) only adds firm fixed effects, and column (4) reports the estimation results, including the controlling variables and firm fixed effects. We find that increased trade policy uncertainty promotes the digital transformation of Chinese export firms, and the coefficients are statistically and economically significant. According to the results in column (4), it can be seen that each unit increase in trade policy uncertainty will increase the level of digital transformation of export enterprises by 4.439 percentage points.

Taking into account other variables, the size of the export firm is significantly positive, indicating that the higher the scale of the export firm, the higher the level of digital transformation. The coefficient of ownership concentration (Shrcr) is significantly positive, indicating that the more concentrated the ownership of export firms, the more conducive it is to digital transformation. The coefficient of Tobin's Q value (TobinQ) is significantly positive, indicating that export firms with higher growth potential are better able to carry out digital transformation when trade policy uncertainty increases.

**Table 2: Benchmark regression**

Variables	(1)	(2)	(3)	(4)
	lnEDT	lnEDT	lnEDT	lnEDT
<b>TPU</b>	0.17866*** (32.91)	0.05602*** (12.00)	0.14473*** (29.86)	0.04439*** (11.59)
<b>GDP</b>		-0.06605*** (-25.22)		-0.05646*** (-23.00)
<b>MZ</b>		-5.05832*** (-23.40)		-4.63011*** (-20.36)
<b>BP</b>		-0.61824** (-2.51)		-0.74109*** (-3.56)
<b>Manage</b>		1.24680*** (4.14)		-0.47462** (-2.53)
<b>size</b>		0.20610*** (11.60)		0.28291*** (11.02)
<b>Yb</b>		0.17487*** (4.50)		0.00816 (0.30)
<b>Auppt</b>		0.26087*** (3.59)		0.01150 (0.26)
<b>Shrcr</b>		-0.00758*** (-5.67)		-0.00990*** (-5.27)
<b>TobinQ</b>		0.06066*** (4.47)		0.05267*** (5.37)
<b>Zroa</b>		-0.97203*** (-4.40)		-0.69725*** (-5.39)
<b>Fixa</b>		-2.79243*** (-21.37)		-1.02329*** (-7.87)
<b>_cons</b>	0.64893*** (28.63)	1.44349*** (4.15)	0.73216*** (61.57)	1.05441*** (3.14)
<b>Firm fixed effects</b>	No	No	Yes	Yes
<b>N</b>	22797	22797	22797	22797
<b>R-sq</b>	0.067	0.230	0.722	0.772

Note: The t-value is enclosed in parentheses; \*, \*\*, and \*\*\* represent 10%, 5%, and 1% significance levels, respectively.

## 6.2 Mechanisms Tests

Furthermore, this paper uses the following method to examine the influence mechanism through which trade policy uncertainty affects the digital transformation of Chinese export firms:

$$QCT_{iqt} = \beta_0 + \beta_1 TPU_t + \sum \beta_i control_{iqt} + \delta_i + \mu_{iqt} \quad (2)$$

$$lnEDT_{iqt} = \beta_0 + \beta_1 TPU_t + QCT_{iqt} + \sum \beta_i control_{iqt} + \delta_i + \theta_{iqt} \quad (3)$$

$$lnEDT_{iqt} = \beta_0 + \beta_1 TPU_t + \beta_2 TPU_t \times MD_{iqt} + \sum \beta_i control_{iqt} + \delta_i + \varepsilon_{iqt} \quad (4)$$

Formula (2) regresses the intermediary variable and the independent variable. Formula (3) regresses the dependent variable against the independent variable and the intermediary variable.  $QCT_{iqt}$  is the intermediary variable trade cost (TC), which adopts the indirect measurement method commonly used in the literature, using exports to represent bilateral trade, and the difference between GDP and exports to represent domestic trade. If bilateral trade increases relative to domestic trade, trade costs will decrease. The trade costs in this paper include China's major trading countries, which are the United States, Japan, South Korea, the United Kingdom, France, Germany, and Italy. The data used is from the National Bureau of Statistics of China. Formula (4) adds the interaction term of trade policy uncertainty and mediation variables in the benchmark regression ( $TPU_t \times MD_{iqt}$ ),  $MD_{iqt}$  is the mediation variables of foreign investment (FI) and financing constraints (FC). The variable of the financing constraint is also represented by the WW financing constraint index. The data comes from the CSMAR database. The above controlling variables and fixed effects remain consistent with the baseline regression.

### **6.2.1 The trade cost channels of trade policy uncertainty affecting firms' export transformation**

The results of the influence mechanism of trade costs are shown in Table 3. It shows the results of trade policy uncertainty in the current period and the lagged one and two terms, respectively. As a result, the coefficients of trade policy uncertainty are all significantly positive, but from columns (1) and (2) of Table 3, it can be seen that the mechanism by which trade policy uncertainty forces export firms to accelerate digital transformation through trade costs is not reasonable in the current period, the results are in line with expectations in the first lagged period, and the coefficient of trade policy uncertainty in the second lagged period is significantly lower than that of the baseline regression. This shows that there are delayed effects in the process because the increasing trade policy uncertainty accelerates the digital transformation of exports through trade costs. That is, increased trade policy uncertainty will lead to an increase in trade costs in the future, which will in turn force export firms to accelerate digital transformation to resolve the future crisis of rising trade costs. In fact, the impact of uncertainty on cash flow fluctuations, risks, investments, and mergers and acquisitions may have delayed effects (Nguyen & Phan, 2017), and the delayed impact of trade policy uncertainty on trade costs is also reasonable.

**Table 3: Influence mechanism of the trade cost**

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	TC	lnEDT	TC	lnEDT	TC	lnEDT
TPU	-0.00119*** (-29.31)	0.06895*** (16.80)				
L.TPU			0.00206*** (43.59)	0.05592*** (12.73)		
L2.TPU					0.00294*** (41.82)	0.02625*** (5.26)
TC		0.50547** (2.48)		0.94787*** (5.01)		2.63498*** (6.50)
_cons	-0.40438*** (-64.38)	2.24135*** (6.07)	-0.03995*** (-8.46)	3.24434*** (8.98)	0.31422*** (55.34)	2.48710*** (6.65)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	20783	20783	17074	17074	14579	14579
R-sq	0.418	0.279	0.247	0.283	0.568	0.265

Note: The t-value is enclosed in parentheses; \*, \*\*, and \*\*\* represent 10%, 5%, and 1% significance levels, respectively.

### 6.2.2 The foreign investment and financing constraints channels of trade policy uncertainty affecting firms' export transformation

The experimental results of hypothesis 3 are shown in Table 4. The coefficient of the interaction term of foreign investment and trade policy uncertainty (FI×TPU) is significantly positive, indicating that the positive impact of trade policy uncertainty on the digital transformation of Chinese export firms is more obvious among export firms with higher levels of foreign investment. This result supports hypothesis 3. Export firms with higher levels of foreign investment not only have more funds, but also enjoy the technological spillover effects brought by foreign investment. Faced with rising trade policy uncertainty, export firms have more available funds for digital transformation. If foreign investment appears in the form of technology, export firms will have more technical advantages and conveniences in digital transformation, thus improving the overall digital transformation level of export firms.

The coefficient of the interaction term of financing constraints and trade policy uncertainty (FC×TPU) is significantly negative, indicating that the positive relationship between trade policy uncertainty and the digital transformation of export firms is more significant among export firms with lower financing constraints, supporting hypothesis 3. The higher the financing constraints of export firms, the greater the obstacles to digital transformation. Faced with the increase in

trade policy uncertainty, export firms will reduce investment activities and lower the input of digital transformation to reduce risks. Column (3) uses the WW index of financing constraints to conduct an empirical study again, and the results still show the weakening effect of financing constraints.

**Table 4: Results of the foreign investment and financing constraints impact mechanism**

Variables	(1)	(2)	(3)
	<b>lnEDT</b>	<b>lnEDT</b>	<b>lnEDT</b>
<b>TPU</b>	0.05771***	0.08980***	0.06282***
	(11.41)	(11.14)	(8.51)
<b>FI × TPU</b>	0.00000***		
	(4.72)		
<b>FC × TPU</b>		-0.05414***	
		(-3.62)	
<b>WW × TPU</b>			-0.01311**
			(-2.39)
<b>_cons</b>	1.95930***	2.27398***	1.97476***
	(5.63)	(5.89)	(5.28)
<b>Control variables</b>	Yes	Yes	Yes
<b>Firm fixed effects</b>	Yes	Yes	Yes
<b>N</b>	19317	17852	16596
<b>R-sq</b>	0.773	0.775	0.753

Note: The t-value is enclosed in parentheses; \*, \*\*, and \*\*\* represent 10%, 5%, and 1% significance levels, respectively.

## 6.3 Robustness Checks

### 6.3.1 Instrumental variable estimation

This paper uses the instrumental variable method to alleviate the endogeneity problem in the model. Based on the existing literature, we use the trade policy uncertainty index of the United States (IV1) and the weighted trade policy uncertainty index of the United States and Japan calculated by the weighting method as instrumental variables (IV2). The results are shown in Table 5, where columns (1) and (3) show that instrumental variables IV1 and IV2 have a positive impact on the trade policy uncertainty index. The results after adding instrumental variables to deal with the endogeneity problem are shown in columns (2) and (4). A significantly positive trade policy uncertainty coefficient is reported at the 1% significance level, indicating that our conclusions do not change after alleviating the endogeneity problem. The KP-LM statistic passed the over-identification test significantly, and the CD-F statistic was greater than the maximum critical value and passed the weak instrumental variable test.

**Table 5: Robust checks-Instrumental variable estimation (2SLS estimation)**

<b>Variables</b>	<b>(1)</b>	<b>(2)</b>	<b>(3)</b>	<b>(4)</b>
	<b>First</b>	<b>Second</b>	<b>First</b>	<b>Second</b>
	TPU	lnEDT	TPU	lnEDT
<b>TPU</b>		0.04489***		0.01421***
		(0.004)		(0.004)
<b>IV1</b>	0.03373***			
	(0.000)			
<b>IV2</b>			0.02042***	
			(0.000)	
<b>Control variables</b>	Yes	Yes	Yes	Yes
<b>Firm fixed effects</b>	Yes	Yes	Yes	Yes
<b>Observations</b>	22,797	22,797	22,797	22,797
<b>R-squared</b>		0.273		0.271
<b>Kleibergen-Paap rk LM statistic</b>		1871.584***		1907.782***
		0.000		0.000
<b>Cragg-Donald Wald F statistic</b>		6.6e+04 [16.38]		4.7e+04 [16.38]

Note: Standard errors of the corresponding variables are in parentheses; \*, \*\*, and \*\*\* represent 10%, 5%, and 1% significance levels, respectively.

### 6.3.2 Replace independent and dependent variable tests

To ensure the reliability of the study results, we further used additional independent variables (TPU2, TPU3, and TPU4). Specifically, TPU2 uses the weighted average method to assign the weight of the corresponding month to each month. TPU3 is represented by the data of the 12th month of the year, and TPU4 uses the data of Wu et al. (2021). The results, as shown in columns (1) to (3) of Table 6, are significantly positive, indicating that trade policy uncertainty has increased the level of digital transformation of Chinese export firms, and these results further support hypothesis 1.

### 6.3.3 Two-way clustering and province-fixed effects tests

We use two-way (firm and year) clustering to solve the problem of disturbance terms. The results are shown in column (4) of Table 6. Through two-way clustering, we find that trade policy uncertainty significantly promotes the digital transformation of export firms, further supporting our research hypothesis 1. In order to test the effect at the province level, we controlled the province-fixed effects in the model. The results are shown in column (5) of Table 6. Trade policy uncertainty has a significant positive impact on the digital transformation of export firms. Hypothesis 1 was verified.

**Table 6: Robustness checks**

Variables	(1)	(2)	(3)	(4)	(5)
	lnEDT	lnEDT	lnEDT	lnEDT	lnEDT
<b>TPU2</b>	0.00033***				
	(9.98)				
<b>TPU3</b>		0.00028***			
		(9.57)			
<b>TPU4</b>			0.08969***		
			(22.30)		
<b>TPU</b>				0.04439*	0.04420***
				(2.04)	(11.54)
<b>_cons</b>	0.96602***	0.76690**	3.92306***	1.05441	1.08090***
	(2.87)	(2.25)	(9.79)	(0.90)	(3.22)
<b>Control variables</b>	Yes	Yes	Yes	Yes	Yes
<b>Firm fixed effects</b>	Yes	Yes	Yes	Yes	Yes
<b>Province fixed effect</b>	No	No	No	No	Yes
<b>N</b>	22797	22797	16561	22797	22797
<b>R-sq</b>	0.772	0.771	0.792	0.772	0.773

Note: The column (4) clusters to the firm and year levels, and the other clusters to the firm level. The t-value is enclosed in parentheses; \*, \*\*, and \*\*\* represent 10%, 5%, and 1% significance levels, respectively.

#### **6.4 Heterogeneous effects of trade policy uncertainty on the digital transformation of export firms**

This paper further studies whether the impact of TPU on the digital transformation of Chinese export firms differs depending on the level of digital development of industries and regions. According to the Digital Whirlpool Report released by the Global Digital Business Transformation Center in 2021, the five industries of media and entertainment, retail, telecommunications, technology products and services, and financial services are at the center of the digital whirlpool, and their digital processes and digital capabilities are stronger than those of other industries. Export firms in these five industries are set to 1, and export firms in other industries are set to 0. Based on the method of calculating the digital economy in the existing literature, we calculated the comprehensive digital economy index of each region based on the availability, usage conditions, and usage skills of digital transformation and assigned corresponding weights. Regions above the average are set to 1, and those below the average are set to 0. The results of the level of industry digitalization are shown in columns (1) and (2) of Table 7. This result shows that the digital transformation of export firms in industries on the edge of the digital vortex is more affected by TPU; that is, the digital transformation of export firms with slower digital processes and weaker digital capabilities is more affected by the uncertain environment. The results of regional digitalization levels are shown in columns (3)

and (4) of Table 7. This shows that trade policy uncertainty can better promote the digital transformation of export firms in areas with a low level of digital economic development; that is, in the context of increasing uncertainty in trade policies, export firms in relatively backward digital regions can actively seek innovation and actively promote digital transformation.

**Table 7: Digitalization differences across industries and regions**

Variables	(1)	(2)	(3)	(4)
	lnEDT	lnEDT	lnEDT	lnEDT
<b>TPU</b>	0.03678***	0.04310***	0.05472***	0.07701***
	(3.56)	(10.37)	(8.97)	(13.77)
<b>_cons</b>	4.90332**	0.50224	2.57578***	1.70274***
	(2.45)	(1.45)	(4.98)	(3.74)
<b>Control variables</b>	Yes	Yes	Yes	Yes
<b>Firm fixed effects</b>	Yes	Yes	Yes	Yes
<b>N</b>	2654	20083	9747	10508
<b>R-sq</b>	0.892	0.728	0.761	0.780
<b>Experiential P-value</b>	0.000		0.000	

Note: Standard errors of the corresponding variables are in parentheses; \*, \*\*, and \*\*\* represent 10%, 5%, and 1% significance levels, respectively.

## 7. Conclusion

In order to explore the impact of trade policy uncertainty on the digital transformation of export firms, this paper conducts empirical research on Chinese listed firms from 2007 to 2022. Research shows that trade policy uncertainty significantly promotes the digital transformation of Chinese export firms, which shows that when trade policy uncertainty intensifies, export firms tend to accelerate digital transformation to improve their digital capabilities to cope with crises caused by trade policy uncertainty. Meanwhile, the increase in trade policy uncertainty will increase the trade costs faced by export firms, which will in turn force export firms to accelerate digital transformation and use digital technology and digital capabilities to reduce trade costs. The current uncertainty faced by the global economy is intensifying. The research in this paper has important significance. In order to reduce the increase in trade costs caused by trade policy uncertainty, most countries are vigorously developing the digital economy based on their own economic conditions. The trend of digital transformation is spreading around the world, and the global digital level is accelerating to higher levels. In addition, we found that foreign investments can strengthen the promoting effect of trade policy uncertainty on the digital transformation of Chinese export firms, while financing constraints can weaken this promoting effect. This finding is of great significance to the government. When formulating macroeconomic policies, the government should try to reduce the financing constraints faced by export firms as much as possible and implement active investment policies to introduce foreign investment,



which can help domestic export firms accelerate the digital transformation and improve national digital capabilities. Finally, this paper explores the impact of trade policy uncertainty on the digital transformation of Chinese export firms when industries and regions have different levels of digital development. The study shows that trade policy uncertainty has a greater impact on industries and regions with relatively backward digital levels. This discovery will help to balance the digital economy in various regions and industries, and improve the digitalization level.

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### References

- [1] Zhang, W. and Liu, X. (2023). The impact of internet on innovation of manufacturing export enterprises: Internal mechanism and micro evidence. *Journal of Innovation and Knowledge*, 8(3), pp.100377.
- [2] Kraus, S., Durst, S., Ferreira, J.J., Veiga, P., Kailer, N. and Weinmann, A. (2022). Digital transformation in business and management research: An overview of the current status quo. *International Journal of Information Management*, pp.6.
- [3] Wang, H., Shen, H., Tang, X., Wu, Z. and Ma, S. (2021). Trade policy uncertainty and firm risk taking. *Economic Analysis and Policy*, 70, pp.351–64.
- [4] Akter, S., Biswas, K., Vrontis, D., Cooper, S.C.L. and Tarba, S.Y. (2023). Mastering digital transformation in workforce management. *Production Planning & Control*, pp.1–8.
- [5] Staka, Z., Vukovic, M. and Vujovic, V. (2022). The Role of Digital Competencies in the Process of Digital Transformation. 21ST International Symposium INFOTEH-JAHORINA, pp.1–6.
- [6] Zhu, Z., Song, T., Huang, J. and Zhong, X. (2022). Executive Cognitive Structure, Digital Policy, and Firms' Digital Transformation. *IEEE Transactions on Engineering Management*, pp.1–14.
- [7] Miklosik, A., Kraha, A.B. and Evans, N. (2023). Disruptions Leading to Digital Business Transformation: Executives' Perceptions. *IEEE Access*, 11, pp.102860–70.
- [8] Mutlu, I., den Hartigh, E. and Ucler, C. (2022). Digital Technology and the Stages of Digital Business Transformation. 2022 IEEE 28TH International Conference on Engineering, Technology and Innovation, pp.1–8.

- [9] Omrani, N., Rejeb, N., Maalaoui, A., Dabic, M. and Kraus, S. (2022). Drivers of Digital Transformation in SMEs. *IEEE Transactions on Engineering Management*, pp.1–14.
- [10] Liu, X., Wang, X., and Yu, W. (2023). Opportunity or Challenge? Research on the Influence of Digital Finance on Digital Transformation of Agribusiness. *Sustainability*, 15(2), pp.1072.
- [11] Ianenko, M., Ianenko, M., Kirillova, T., Amakhina, S. and Nikitina, N. (2020). Digital transformation strategies of trade enterprises: Key areas, development and implementation algorithms. IOP Publishing, 940(1).
- [12] Jiang, M. and Jia, P. (2022). Does the level of digitalized service drive the global export of digital service trade? Evidence from global perspective. *Journal of Cleaner Production*, 72, pp.101853.
- [13] Wang, D. and Chen, S. (2022). Digital transformation and enterprise resilience: Evidence from China. *Resources Policy*, 87.
- [14] Hu, D., Lu, J. and Zhao, S. (2024). Does trade policy uncertainty increase commercial banks' risk-taking? Evidence from China. *International Review of Economics and Finance*, 10, pp.44.
- [15] Wang, F. and Wu, M. (2023). How does trade policy uncertainty affect China's economy and energy? *Journal of Environmental Management*, 330, pp.117198.
- [16] Zhou, F. and Wen, H. (2022). Trade policy uncertainty, development strategy, and export behavior: Evidence from listed industrial companies in China. *Journal of Asian Economics*, 82, pp.101528.
- [17] Liu, Q., Li, Y., Li, S. and Wu, F. (2023). Lose to gain: Heterogeneous impact of trade policy uncertainty on firms' domestic sales. *Economic Modelling*, 119(2022), pp.106118.
- [18] Crowley, M., Meng, N. and Song, H. (2018). Tariff scares: Trade policy uncertainty and foreign market entry by Chinese firms. *Journal of International Economics*, 114, pp.96–115.
- [19] Fan, X. (2021). Digital Economy and Exports: An Analysis Based on a Heterogeneous Stochastic Frontier Model. *World Economic Studies*, pp.1–23.
- [20] Yu, M., Fan, J., Wang, H. and Wang, J. (2023). US trade policy uncertainty on Chinese agricultural imports and exports: An aggregate and product-level analysis. *International Review of Economics and Finance*, 84, pp.70–83.
- [21] Bermepe, T., Karadimitropoulou, A., Triantafyllou, A. and Alshalhi, J. (2023). Does commodity price uncertainty matter for the cost of credit? Evidence from developing and advanced economies. *Journal of Commodity Markets*, 29, pp.100306.
- [22] Liu, J. and Wang, H. (2022). Economic policy uncertainty and the cost of capital. *International Review of Financial Analysis*, 81, pp.102070.
- [23] Xiang, J. and Li, L. (2022). Monetary policy uncertainty, debt financing cost and real economic activities: Evidence from China. *International Review of Economics and Finance*, 80, pp.1025–44.

- [24] Yang, S., Shi, B. and Yang, F. (2023). Macroeconomic impact of the Sino–U.S. trade frictions: Based on a two-country, two-sector DSGE model. *Research in International Business and Finance*, 65, pp.101956.
- [25] Zhao, T., Yan, N. and Ji, L. (2023). Digital transformation, life cycle and internal control effectiveness: Evidence from China. *Finance Research Letters*, 58, pp.104223.
- [26] Peng, Y. and Tao, C. (2022). Can digital transformation promote enterprise performance? —From the perspective of public policy and innovation. *Journal of Innovation and Knowledge*, 7(3), pp.100198.
- [27] Zhu, S., Shen, Z., Wen, Q. and Duan, F. (2023). Economic Policy Uncertainty and Firms' Digital Strategies: Effects and Mechanisms. *Quantitative Economics, Technical Economics, and Economics*, pp.1–23.
- [28] Yang, Z., Chen, J. and Wu, H. (2023). "Embrace" or "Rejection": Economic Policy Uncertainty and Digital Transformation of Enterprises. *Economist*, pp.45–54.
- [29] Liu, X. and Wang, C. (2003). Does foreign direct investment facilitate technological progress?: Evidence from Chinese industries. *Research Policy*, 32(6), pp.945–53.
- [30] Hiep, T.D., Trung, B.H. and Van Chien, L. (2022). Quantifying productivity gains from foreign direct investment: The mediating role of provincial institutional quality. *Finance Research Letters*, 49, pp.103174.
- [31] Chen, Y., Jiang, H., Liang, Y. and Pan, S. (2022). The impact of foreign direct investment on innovation: Evidence from patent filings and citations in China. *Journal of Comparative Economics*, 50(4), pp.917–45.
- [32] Li, Q., Chen, H., Chen, Y., Xiao, T. and Wang, L. (2023). Digital economy, financing constraints, and corporate innovation. *Pacific Basin Finance Journal*, 80, pp.102081.
- [33] Caggese, A., Cuñat, V. and Metzger, D. (2019). Firing the wrong workers: Financing constraints and labor misallocation. *Journal of Financial Economics*, 133(3), pp.589–607.
- [34] Dou, B., Guo, S.L., Chang, X.C. and Wang, Y. (2023). Corporate digital transformation and labor structure upgrading. *International Review of Financial Analysis*, 90, pp.102904.
- [35] Wu, F., Hu, H., Lin, H. and Ren, X. (2021). Corporate Digital Transformation and Capital Market Performance: Empirical Evidence from Equity Liquidity. *Manage the world*, pp.130–44.
- [36] Kang, W., Lee, K. and Ratti, R.A. (2014). Economic policy uncertainty and firm-level investment. *Journal of Macroeconomics*, 3, pp.42–53.
- [37] Li, M., Li, Z., Chen, J. and Lian, Y. (2022). Economic policy uncertainty and the long-term use of corporate short-term debt. *Manage the world*, 38(01), pp.77-89+143+90-101.
- [38] Nguyen. N.H., Phan and H.V. (2017). Policy Uncertainty and Mergers and Acquisitions. *Journal of Financial and Quantitative Analysis*, 52, pp.613–644.