The Influence of Exchange Rate Fluctuations on Enterprise Innovation ——Panel Data Analysis Based on Stata

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Abstract—This paper illustrates the theoretical mechanism of the exchange rate fluctuation affecting the enterprise innovation and foreign exchange risk hedging playing a moderating role on it. We think that the exchange rate fluctuation on enterprise innovation may produce "incentive effect" or "inhibition effect". However, on the whole, the exchange rate fluctuation is not conducive to enterprise innovation. And foreign exchange risk hedging can ease the "inhibition effect" of exchange rate fluctuation on enterprise innovation by alleviating enterprise insufficient R&D investment and encouraging risk-taking behavior. This paper uses Stata software for analysis. On this basis, based on the GARCH (1, 1) model, this paper uses the RMB real effective exchange rate index from 2007 to 2015 to calculate the RMB exchange rate volatility, and uses the patent data of Chinese listed companies and the data of foreign exchange derivatives to build the fixed effect regression model for empirical research. The results show that the increase of exchange rate volatility will inhibit the number of patent applications of listed companies, and the increase in the use of foreign exchange derivatives can alleviate the "inhibition effect" of the increase of exchange rate volatility on enterprise innovation.

Keywords-Financial risk control; Exchange rate fluctuation; Foreign exchange risk hedging; Enterprise innovation; Stata;

1 Introduction

The report of the 19th National Congress of the Communist Party of China pointed out that innovation is the first driving force for development and the strategic support for building a modern economic system, and innovation should be vigorously promoted. Han Jian and Yan Bing (2013) believe that the main body of national R&D innovation is enterprises. The innovation capability of enterprises is constantly improving and has gradually become a key driving force for China's economic development. With the development of China's economy, the degree of opening to the outside world is also constantly improving. Since the "exchange reform" in July 2005, the marketization of the RMB exchange rate has been continuously improved, and the fluctuation of the RMB exchange rate has gradually become the norm. The intensification of exchange rate volatility has led to more companies being impacted by foreign exchange risks, and even suffered heavy losses. In order to meet the potential foreign exchange risk management needs of enterprises, the People's Bank of China has actively promoted the construction of the foreign exchange market while implementing the reform of the RMB exchange rate. The People's Bank of China has successively launched foreign

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exchange services such as forwards, swaps and options in the inter-bank foreign exchange market, and developed and improved the foreign exchange derivatives market. More and more enterprises have begun to use foreign exchange derivatives to hedge foreign exchange risks.

In recent years, the impact of exchange rate fluctuations on exports has attracted the attention of some scholars. However, the literature on the impact of exchange rate volatility and foreign exchange risk hedging on firm innovation is still scarce. Moreover, the relevant factors selected by the existing research are only limited to one aspect. Whether foreign exchange risk hedging can moderate the impact of exchange rate fluctuations on enterprise innovation remains to be explored. It can be seen that in-depth research on the impact of exchange rate fluctuations on enterprise innovation and the adjustment role of foreign exchange risk hedging has profound practical significance. The marginal contribution of this paper is mainly reflected in the consideration of whether foreign exchange risk hedging can alleviate or enhance the impact of exchange rate fluctuations on enterprise innovation on the basis of studying the impact of exchange rate fluctuations on enterprise innovation.

The rest of this paper is arranged as follows: the second part is the literature review, the third part is the theoretical mechanism, the fourth part is the data source and model setting, the fifth part is the empirical results and analysis, and the sixth part is the conclusion and policy recommendations.

2 Theoretical Mechanism

The continuous scientific research and innovation of enterprises requires stable cash flow and profitability. Many studies (such as Hu, 2001; Hall, 1992; Xie Weimin et al., 2009) have found that the level of corporate cash flow significantly promotes the level of corporate innovation investment. On the one hand, the continuous investment of enterprise resources is a necessary guarantee for innovation research; on the other hand, the relatively rigid salary demand for high-tech talents. The "inhibitory effect" of exchange rate fluctuations on enterprise innovation is reflected in: on the one hand, exchange rate fluctuations have a certain impact on the cash flow of enterprises. Dai Mi and Yu Miaojie (2011) [1] found that when exchange rate fluctuations are relatively stable, the increase in the export volume of enterprises can improve their profit level, so enterprises can have relatively stable cash flow for their own R&D and innovation work. On the other hand, long-term investment is not only related to current cash flow, but will also incur exit and maintenance costs in the future, so future cash flow will also significantly affect investment. When the exchange rate volatility increases, the company's management's prediction of the future cash flow level may be biased, so the company's management will be more cautious.

Firms' innovation activities are constrained by high adjustment costs and unstable financing sources. Ju Xiaosheng et al. (2013) [2] found that working capital plays an important role in buffering corporate innovation investment fluctuations. There are two main sources of innovation investment funds for enterprises: internal financing and external financing. Li Huidong et al. (2013) [3] found that both sources can promote corporate innovation investment. Although Chinese listed companies prefer to use funds obtained from external financing to support R&D activities, the use of derivatives to hedge foreign exchange risks can reduce the volatility of internal cash flow to a certain extent. Promote innovation (Smith and Stulz, 1985;

Bessembinder, 1991; Froot et al., 1993).

In terms of alleviating the lack of corporate R&D investment, the impact of hedging foreign exchange risks is mainly reflected in three aspects: First, the use of derivatives to hedge foreign exchange risks can reduce corporate financial risks, improve corporate financing capabilities and reduce financing costs (Smith and Stulz, 1985; Stulz, 1996). Second, hedging foreign exchange risk can alleviate the underinvestment in R&D caused by agency problems (Smith and Stulz 1, 1985; Bessembinder, 1991). Finally, hedging foreign exchange risks can better adjust the demand and supply of internal funds, and alleviate the lack of R&D investment caused by excessive external financing costs (Froot et al., 1993). In terms of encouraging corporate risk-taking behavior, the impact of hedging foreign exchange risk is mainly reflected in two aspects. On the one hand, hedging the cash flow volatility and financial crisis cost reduction caused by foreign exchange risk can reduce the probability of innovation interruption (Hall and Lerner, 2010), thereby increasing the willingness of enterprises to invest in high-risk innovation projects. On the other hand, hedging foreign exchange risk to alleviate the agency problem can not only encourage firms to increase R&D investment, but also encourage managers to take risks (Smith and Stulz, 1985).

However, the premise of the above conclusion is that companies use foreign exchange derivatives for the purpose of hedging foreign exchange risks or hedging. If a business uses derivatives for speculation, instead of falling, business cash flow volatility may increase. In addition to the impact of speculative behavior, the strengthening of fair value accounting requirements and information disclosure can also cause the use of foreign exchange derivatives to deviate from the purpose of hedging risks.

On the other hand, exchange rate fluctuations also have an "incentive effect" on corporate innovation. Through innovation, companies can gain market power and excess profits. Therefore, when enterprises face market competition and risks, they tend to accelerate innovation to a certain extent to enhance market power (Aghion, 2005) [4]. The fluctuation of foreign exchange risk increases, and the market risk also increases, which to a certain extent will prompt enterprises to increase investment in innovation to maintain or regain market power. In addition, uncertainty is a key source of corporate earnings (Knight, 1921), and uncertainty encourages entrepreneurs to invest more in innovation to a certain extent.

Accordingly, this paper proposes the following hypothesis:

Hypothesis 1: The exchange rate fluctuations faced by enterprises will significantly inhibit their own innovation activities.

Hypothesis 2: Foreign exchange risk hedging can help companies overcome the inhibitory effect of exchange rate fluctuations on corporate innovation.

3 Data Sources and Model Settings

3.1 Measurement model

According to the theoretical analysis in the previous section, for Hypothesis 1, the following measurement model is adopted:

$$\ln\_apply_{it} = \alpha_0 + \alpha_1 \ln\_volatility_t + \sum_m b_m X_{it} + \varepsilon_i + \varepsilon_{it} \quad (1)$$

For Hypothesis 2, the following econometric model is used:

$$ln\_apply_{it} = \alpha_0 + \alpha_1 ln\_volatility_t + \alpha_2 ln\_volatility_t \times scale_{it} + \sum_m b_m X_{it} + \varepsilon_i + \varepsilon_{it} \quad (2)$$

Among them, i represents the enterprise, and t represents the time. The explanatory variable ln_applyit is the logarithm of the number of patents filed by firm i in period t. scaleit is the transactional financial asset scale of enterprise i in year t. ln_volatilityt is the logarithm of the exchange rate volatility in year t. Xim is the control variable of firm i, and this paper controls firm size and firm age at firm level. εi is a firm-level fixed effect, which controls the characteristics of firms that do not change over time and solves the problem of some missing variables. εit is a random disturbance term.

3.2 Indicators and data

The explained variable $apply_{it}$. This paper first examines the factors that affect the innovation intensity of enterprises. The data used is the total number of patents that have been applied for by listed companies and their subsidiaries, joint ventures and associates from 2007 to 2015, and ln_apply_{it} is obtained by taking the logarithm of the obtained data. The data comes from the Cathay Pacific database. In the robustness test, the number of issued patents is used instead of the number of patents filed.

The core explanatory variable exchange rate volatility $volatility_t$. This paper uses the 2007-2015 RMB real effective exchange rate index to calculate the exchange rate volatility based on the GARCH (1,1) model, and takes the logarithm of the obtained exchange rate volatility data to obtain $ln\_volatility_t$. Among them, the real effective exchange rate index comes from the WIND database.

The core indicator derivatives trading $scale_{it}$ uses the data of listed companies' tradable financial assets. The contractual nominal value of the financial assets held for trading is equal to (the fair value at the beginning of the period + the fair value at the end of the period) ÷ 2. Among them, the data of trading financial assets comes from the Ruisi database.

Control variable X_{im}. In order to reduce the measurement endogeneity problem caused by omitted variables as much as possible, this paper adds enterprise-level control variables including enterprise asset (asset) and enterprise age (age), and takes the logarithm of enterprise asset and enterprise age to obtain ln_asset and ln_age. Both corporate assets and corporate age data come from the Cathay Pacific database.

3.3 Calculate exchange rate volatility based on GARCH (1,1)

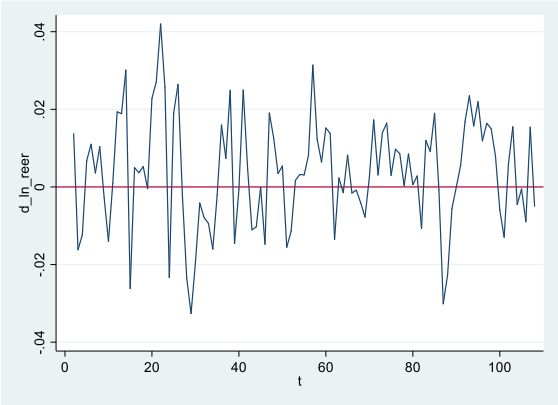

Figure 1 Logarithmic difference series of RMB real effective exchange rate index from 2007 to 2015

This paper uses the GARCH (1,1) model to measure exchange rate volatility. First, the effective exchange rate index is further analyzed and processed using the logarithmic difference method to obtain the logarithmic difference sequence of the effective exchange rate index. After testing, the logarithmic difference series of the RMB real effective exchange rate index is stationary. From the figure, the existence of volatility agglomeration can be clearly found. To test whether there is an ARCH effect, the p-value is 0.0005, rejecting the null hypothesis that there is no ARCH effect. Considering the autoregressive model, most criteria choose the AR (1) model and use OLS to estimate the AR (1) model, where the coefficient of the first-order lag is significantly non-zero. The LM test was performed on whether there was an ARCH effect in the OLS residuals, which showed that the first-order lag was significant. Fit the GARCH (1,1) model to obtain the conditional variance σ_t of ε_t at time t that depends on the square of the residual of the previous period ε_{t-1}^2 (ie the ARCH term) and the forecast variance σ_{t-1} of the previous period (ie GARCH item)

$$\sigma_t^2 = 0.0000134 + 0.0909432\varepsilon_{t-1}^2 + 0.8313638\sigma_{t-1}^2 \quad (3)$$

The test showed that the ARCH term and the GARCH term showed joint significance.

3.4 Descriptive statistics

The statistical analysis of the main variables in the model regression involved in this paper is shown in Table 1. When the dependent variable is the number of applied patents, the sample contains 763 listed companies, and the regression sample size is 2825. After processing the explanatory variables and control variables by one lag, the sample contains a total of 564 listed companies, and the total regression sample size is 1880. When the dependent variable is the number of granted patents, the sample contains 746 listed companies, and the regression sample size is 2740.

Table 1 Descriptive Statistics

variable	definition	number of observations	mean	minimum	maximum value	standard deviation
ln_apply_{it}	The number of patents filed by firm i in year t (logarithm)	2825	3.0858	0	8.6458	1.7210
$ln\_apply\_grant_{it}$	Number of patents granted by firm i in year t (logarithm)	2740	2.9269	0	8.5510	1.7060
$scale_{it}$	Scale of transactional financial assets of firm i in year t	2825	2.12e+09	-1.05e+07	4.27e+11	2.04e+10
$ln\_volatility_t$	t Annual exchange rate volatility (log)	2825	0.6559	0.5217	0.8966	0.1231
ln_asset	Business assets (logarithmic)	2825	22.6469	19.4	30.7	1.8268
ln_age	Business age (logarithmic)	2825	2.6169	-1.1087	3.5625	0.4588

4 Empirical Results and Analysis

4.1Benchmark regression results

In the empirical study, this paper firstly uses the number of patents applied by enterprises to measure the innovation index of enterprises, and measures the intensity of foreign exchange risk hedging by the scale of trading financial assets used. Through the Hausman test, this paper adopts a short-panel individual fixed-effects model to conduct relevant empirical analysis. The specific regression results are shown in Table 2.

Table 2 shows the benchmark regression results. The exchange rate volatility and each control variable in the table are in logarithmic form. Column (1) of Table 2 reports the impact of exchange rate volatility on firm innovation. In column (1), no interaction term is added, only the logarithmic value of exchange rate volatility is added, and it is found that the coefficient of the logarithmic value of exchange rate volatility is significantly negative at the 1% level. Column (2) in Table 2 reports that the coefficient of exchange rate volatility is significantly negative at the 1% level when the logarithm of corporate assets is added as a control variable. Column (3) in Table 2 reports that when the log value of corporate assets and the log value of corporate age are added as control variables, the coefficient of exchange rate volatility is still significantly negative at the 1% level. and logarithm of firm age are both significantly positive

at the 1% level. It shows that exchange rate volatility is negatively correlated with enterprise innovation, the degree of exchange rate volatility increases, and the innovation intensity of enterprises decreases.

Enterprise innovation requires a large amount of capital investment, and the increase in exchange rate fluctuations will affect the level of internal cash flow of the enterprise. The use of tradable financial assets by enterprises for the purpose of hedging foreign exchange risks can play a role in stabilizing corporate cash flow. Therefore, we expect that the use of tradable financial assets can adjust the inhibitory effect of exchange rate fluctuations on corporate innovation. In order to verify this conjecture, we further consider the scale factor of the use of transactional financial assets in the regression equation, and explore the moderating effect of the use of transactional financial assets on the impact of exchange rate fluctuations on corporate innovation. Column (4) reports the regression results by adding the cross term of the size of trading financial assets and exchange rate volatility. We find that the cross term coefficient of the size of trading financial assets and exchange rate volatility is significantly positive at the 1% level. Column (5) of Table 2 reports that when the log value of corporate assets is added as a control variable, the coefficient of the log value of exchange rate volatility is significantly negative at the 1% level, and the cross term between the size of trading financial assets and exchange rate volatility The coefficient is significantly positive at the 5% level, and the coefficient of the logarithm value of the control variable enterprise assets is significantly positive at the 1% level. Column (6) of Table 2 reports that when the log value of corporate assets and the log value of corporate age are added as control variables, the coefficient of the log value of exchange rate volatility is significantly negative at the 1% level, and the size of trading financial assets and The cross-term coefficient of exchange rate volatility is significantly positive at the 5% level, and the coefficients of the control variables logarithm of corporate assets and logarithm of corporate age are significantly positive at the 1% level. It shows that with the increase in the use scale of transactional financial assets, the negative impact of exchange rate fluctuations on enterprise innovation gradually weakens, that is, the use of transactional financial assets can alleviate the inhibitory effect of foreign exchange risk hedging on enterprise innovation. And it can be seen from Table 2 that with the addition of control variables, the R2 of the model increases, and the fitting effect improves.

Table 2 Benchmark regression results

	(1)	(2)	(3)	(4)	(5)	(6)
ln_volatility	-1.1829***	-0.5445***	-0.3711***	-1.1968***	-0.5608***	-0.3850***
	(-7.61)	(-3.64)	(-2.63)	(-7.69)	(-3.76)	(-2.78)
scale*ln_volatility				7.71e-12***	4.92e-12**	3.06e-12**
				(4.59)	(2.52)	(2.12)
ln_asset		0.8457***	0.5169***		0.8359***	0.5177***
		(12.47)	(6.90)		(12.34)	(6.93)
ln_age			1.0381***			1.0162***
			(5.88)			(-7.64)
_cons	3.8617***	-15.7104***	-11.0936***	3.8603***	-15.4827***	-11.0493***
	(37.90)	(-10.07)	(-7.66)	(37.80)	(-9.94)	(-7.64)
firm fixed effects	control	control	control	control	control	control
number of observations	2825	2825	2825	2825	2825	2825
R^2	0.0315	0.1826	0.2172	0.0391	0.1856	0.2184

Note: The t value in brackets, ***, ***, and * represent the significance levels of 1%, 5%, and 10%, respectively

4.2 Endogenous problems

On the one hand, this paper argues that there is no endogeneity between exchange rate fluctuations and the propensity of firms to innovate. Whether an enterprise innovates or not is a micro variable, and exchange rate fluctuation is a macro variable. It is difficult for micro variables to affect macro variables in turn, so it is difficult to say that corporate innovation activities will affect the level of exchange rate fluctuations. On the other hand, corporate innovation requires relatively stable cash flow support. Actively innovative companies are more likely to use foreign exchange derivatives to hedge foreign exchange risks. Therefore, there may be a causal relationship between corporate innovation activities and tradable financial assets.

In order to test whether there is an endogeneity problem in the model, the explanatory variable and the control variable are both lagged by one period, and then the fixed effect regression model is used, and the following results are obtained: In column (1), no interaction term is added, and only one lag period is added. The logarithm of exchange rate volatility shows that the coefficient of the logarithm of exchange rate volatility for one lag period is significantly negative at the 1% level. Column (2) reports the logarithm value of corporate assets with a one-period lag of the control variable. It is found that the coefficient of the logarithmic value of exchange rate volatility with a one-period lag is significantly negative at the level of 1%. The logarithmic coefficient is significantly positive at the 1% level. Column (3) reports the logarithm value of corporate assets and the logarithm value of corporate age when the control variables lag one period are added. The coefficients of the logarithm value of enterprise assets lagging one period and the logarithm value of enterprise age lagging one period are significantly positive at the level of 1%. It shows that exchange rate fluctuation is negatively correlated with enterprise innovation.

Column (4) reports the regression results of adding the logarithm of exchange rate volatility and the cross term of the size of trading financial assets with one lag period. We find that the logarithm of exchange rate volatility with one lag period is significantly negative at the 1% level., the cross term coefficient is significantly positive at the 1% level. Column (5) of Table 3 reports that when the log value of corporate assets with a lag period is added as a control variable, the log value of the exchange rate volatility of the lag period is significantly negative at the level of 1%. The cross term coefficient of the scale of trading financial assets in the period is significantly positive at the 10% level, and the coefficient of the logarithmic value of the corporate assets of the control variable lagging one period is significantly positive at the 1% level. Column (6) of Table 3 reports that the logarithm of the exchange rate volatility of the one-lag period is at the 1% level when the logarithm of the assets of the enterprises with a lag period and the logarithm of the age of the enterprises with a lag period of one period are added as control variables. is significantly negative, the cross-term coefficient of exchange rate volatility and the scale of trading financial assets lagging one period is positive, and the logarithm value of the control variable enterprise assets lagging one period and the logarithmic value coefficient of enterprise age are both at the level of 1%. significantly positive. It shows that with the increase of risk hedging of transactional financial assets, the negative impact of exchange rate fluctuations on corporate innovation gradually weakens. And with the increase of control variables, R^2 increases, and the fitting effect of the model is further improved. Therefore, empirical research results show that exchange rate fluctuations have an inhibitory

effect on enterprise innovation, and foreign exchange risk hedging can alleviate the inhibitory effect of exchange rate fluctuations on enterprise innovation.

Table 3 Endogeneity test regression results

	(1)	(2)	(3)	(4)	(5)	(6)
Lln_volatility	-1.0624***	-0.4509***	-0.3457**	-1.0734***	-0.4664***	-0.3602**
	(-6.84)	(-2.90)	(-2.32)	(-6.89)	(-2.99)	(-2.41)
ln_volatility*Lscale				7.80e-12***	5.30e-12*	3.79e-12
				(3.02)	(1.85)	(1.49)
Lln_asset		0.8655***	0.5783***		0.8542***	0.5796***
		(9.42)	(6.25)		(9.29)	(6.30)
Lln_age			0.8186***			0.7918***
			(4.66)			(4.54)
_cons	4.0719***	-15.9546***	-11.6205***	4.0689***	-15.6946***	-11.5762***
	(39.79)	(-7.56)	(-6.10)	(39.59)	(-7.42)	(-6.08)
firm fixed effects	control	control	control	control	control	control
number of observations	1880	1880	1880	1880	1880	1880
R^2	0.0336	0.1743	0.1989	0.0419	0.1781	0.2008

Note: The t value in brackets, ***, ***, and * represent the significance levels of 1%, 5%, and 10%, respectively

4.3 Robustness test

In the benchmark regression, we use the number of patents applied by enterprises to measure enterprise innovation. In order to ensure the robustness of the results, we use the number of patents granted by enterprises to replace the number of patents applied for by enterprises.

Table 4 reports the results of using the number of patents granted by the company to measure the level of innovation. We found that the explanatory variables exchange rate volatility were all significantly negative, the interaction terms were all significantly positive, the control variable corporate assets were all significantly positive, and the control variable corporate age was significantly positive, further verifying the robustness of the results.

Table 4 Effects of Alternative Innovation Variables

	(1)	(2)	(3)	(4)	(5)	(6)
ln_volatility	-1.2715***	-0.7170***	-0.5688***	-1.2858***	-0.7350***	-0.5854***
	(-8.14)	(-4.87)	(-3.99)	(-8.21)	(-4.99)	(-4.12)
scale*ln_volatility				7.64e-12***	5.22e-12***	3.61e-12**
				(6.76)	(3.47)	(3.57)
ln_asset		0.7446***	0.4444***		0.7336***	0.4453***
		(11.45)	(5.97)		(11.28)	(6.02)
ln_age			0.9209***			0.8947***
			(5.65)			(5.52)
_cons	3.7606***	-13.4670***	-9.1721***	3.7595**	-13.2124***	-9.1181***
	(36.74)	(-9.01)	(-6.26)	(36.63)	(-8.85)	(-6.23)
firm fixed effects	control	control	control	control	control	control
number of observations	2740	2740	2740	2740	2740	2740
R^2	0.0376	0.1545	0.1829	0.0455	0.1582	0.1846

Note: The t value in brackets, ***, ***, and * represent the significance levels of 1%, 5%, and 10%, respectively

5 Conclusions and Policy Recommendations

This paper studies the impact of exchange rate fluctuations on the number of innovations in Chinese listed companies. The results show that the increase of exchange rate volatility inhibits the level of enterprise innovation. Not only that, foreign exchange risk hedging can alleviate the inhibitory effect of exchange rate fluctuations on corporate innovation. After controlling for the endogeneity of the model and passing the robustness test, the above conclusion still holds.

Existing studies have focused on analyzing changes in the RMB exchange rate system and the impact of exchange rate changes on corporate innovation investment. Future research can start from the microscopic perspective of risk management and study the impact on the quantity and quality of Chinese corporate innovation. In addition, the existing literature at home and abroad focuses on how the financing, corporate governance and other functions of the financial market affect enterprise innovation, and less on the impact of its risk management function. The impact of foreign exchange risk hedging on corporate innovation needs to be further studied by scholars.

In the context of further opening up and increased exchange rate flexibility, domestic enterprises should change the risk management of exchange rate fluctuations from "passive" to "active". The way for enterprises to manage exchange rate risk includes rational allocation of RMB futures, options and other financial derivatives for risk hedging. In the face of two-way fluctuations in the exchange rate of RMB against foreign currencies, the company can reduce its negative effects on business performance, maintain the stability of cash flow, and ensure sufficient cash flow to invest in innovative research and development.

From the perspective of enterprises, enterprises should adapt to exchange rate fluctuations, conduct reasonable and prudent transactions, focus on the development of their main business, control currency mismatches, and maintain a stable and sustainable financial position. From the national perspective, on the premise of ensuring national economic security, the development of China's foreign exchange market should be accelerated, the types of foreign exchange derivatives should be enriched, the cost of using foreign exchange derivatives should be reduced, and the risk management function of the financial system should be improved to better serve entities' economic innovation.

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