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Use of Derivative and Firm Performance: Evidence from the Chinese Shenzhen Stock Exchange

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Abstract: Financial derivatives have been increasingly used by firms to hedge against financial risks. However, it is still not clear what factors at the firm level lead to firms' derivative use and whether derivative use can generate performance improvement, especially in the context of firms operating in emerging economies. Using the unbalanced panel data consisting of 2529 listed firms from China covering an 11-year period from 2005 to 2015, this study examines these two questions regarding firms' use of financial derivatives. Based on results from the empirical analysis, this study identified operational cash flow, tax shield, R&D investment, and the possibility of bankruptcy, as the firm-level factors that enable firms' decision to invest in financial derivatives. More importantly, empirical findings from this study suggest that a firm's derivative use tends to negatively affect firm performance, rather than improve firm performance. The negative effect of derivative use on firm performance is not consistent between the two groups of the better performer and poorer performer firms. While the poorly performed firms are more likely to use financial derivatives for the purpose of performance improvement, their derivative use tends to further damage, rather than improve, performance. These research findings have theoretical and practical implications.

Keywords: financial derivatives; firm performance; Shenzhen stock exchange of China; state-owned companies; private-owned enterprises



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1. Introduction

Increasing research attention has been paid to the financial instruments of derivative use, due to their increasing popularity with firms. Derivatives refer to the financial investment such as options and futures, which are used to hedge the financial risks from unexpected changes in interest rate, exchange rate, and commodity price. Firms use financial derivatives to hedge their exposure to various sorts of risk in order to increase their firm value. However, the effectiveness of derivative use on risk management and value creation has been debated among researchers. According to Modigliani and Miller in the 1950s, in a perfect market, risk management should not be relevant to a firm's value. In addition, Modigliani and Miller (1958) believe that risk can be actively managed by shareholders through diversifying their investments. Such theory suggests that firms, by simply reducing the variations of their cash flows or firm values, do not create extra value to the shareholders and thus firms should not hedge.

Several academic pioneers have investigated the relationship between hedging by investing in financial derivatives and firm value. Carter et al. (2006) study data from the US airline industry between 1992 and 2003. Allayannis and Ofek (2001) test currency derivatives using a sample of S&P 500 nonfinancial firms from 1993. Guay (1999) collected data from COMPUSTAT on 254 firms from 1990 to 1994 and divided it into derivative users and non-derivative users. These studies, in general, find that using derivatives results in a reduction of the risk and an increase of the firm performance.

The above studies largely focus on firms listed in developed markets where relevant regulations, laws, accounting standards, and enforcements are well established. In contrast to the abundant studies in developed economies, little attention has been paid to developing markets. This has aroused a new question that whether these findings or conclusions also apply to developing/emerging economies. Different from developed markets, the financial markets of emerging countries are less efficient and can be subject to unsound and incomplete laws and regulations. The financial derivative market itself may not be well developed. People's understanding or knowledge of these complicated financial instruments may also be limited. Hence, the effectiveness of the derivatives may be even more debatable than in the developed markets. Moreover, in these kinds of markets, governments sometimes impose administrative controls, which lead to financial markets being distorted towards the direction of government policy. For example, during the Chinese stock market crash in July 2015, the China Securities Regulatory Commission (CSRC) limited stock index futures trading, banned short selling, cut margin ratios, locked up the holdings of large shareholders, and investigated shorting big blocks. In addition, on January 4th, 2016, the CSRC implemented a two-step circuit breaker in the Shenzhen Stock Market, which led to January 7th having a total trading time of only 15 min. After just four days, the CSRC canceled this mechanism. Such practice seems to be suggesting that the financial derivative markets, rather than helping companies in controlling for risks, are particularly dangerous during market turmoil and thus have to be constrained.

This study aims to explore the use of and the effectiveness of using financial derivatives in one of the largest and most important emerging markets—the Chinese stock market. Notably, this study addresses two research questions. The first one is what kind of firms are more likely to use financial derivatives. Put it in another way, what are the common characteristics shared by the firms that have invested in derivative use? The answer to this question is important, as it helps us to have a better understanding of the motivating factors that result in firms' investment in financial derivatives. There has been an abundant number of empirical studies exploring which factors or imperfections cause firms to hedge using derivatives, but the findings remain mixed. For example, [Allayannis and Weston \(2001\)](#), examined the relationship between firm value and the use of foreign currency derivatives by studying 720 large firms from 1990 to 1995. They found that the market value of firms using hedging derivatives is approximately 5% higher than those not using hedging instruments. Similarly, [Carter et al. \(2006\)](#) reported an even higher hedging premium of approximately 10%. Conversely, [Guay and Kothari \(2003\)](#), through studying a sample of nonfinancial derivative users, argue that the use of derivatives is not significantly associated with the value of firms. They argue that this is because the potential premiums on hedging instruments are small compared to cash flows in equity value. [Jin and Jorion \(2006\)](#) used a sample from the United States oil and gas industry to examine the differences between firms using hedging derivatives and those that were not. They found no obvious relationship between using derivatives and a firm's market value. [Carter et al. \(2006\)](#), [Froot et al. \(1993\)](#), and [Bartram et al. \(2009\)](#) examined the relationship between corporate performance and derivative use, and provide evidence that using derivative is unnecessary for avoiding the underinvestment problem, because internal cash and cash equivalent can address this without increasing extra risks.

This study attempts to identify, among our sample companies, which elements or imperfections are contributing to the increasing propensity of companies to hedge using derivatives. Particularly, under the special background of emerging markets such as China, it will be interesting and meaningful to see whether the conclusion would be different from those drawn from the developed markets.

The second question this study explores is how the use of financial derivatives influences corporate performance, which has been relatively missing from the literature on emerging economies. As we discussed before, derivatives could be particularly dangerous or even detrimental if not used properly. Given that financial derivative markets are relatively young and underdeveloped in China, results from our study could provide extra

implication to firms, practitioners as well as market regulators. Furthermore, in Chinese markets, there are two main types of companies: state-owned and privately-owned firms. While enjoying more financial support from the government, the state-owned firms are also subject to government control to a greater extent. By looking at the differences among these two types of companies in their usage of and the effectiveness of derivatives, we may have more findings on how government intervention may affect firms' risk management as well as efficiency.

The main findings of this study are summarized as follows: Firstly, we find that, in the Chinese market, a firms' size, operating cash flow, tax shield, research and development investment, and the possibility of bankruptcy are the main factors that influence a firm's consideration of investing in derivatives. Secondly, the nature of a firm (i.e., whether it is privately-owned or state-owned) is not a deciding factor in derivative investment. Thirdly, derivative usage has a negative influence on the performance of firms, and such a finding is not altered by whether the firms are state-owned or not. Additionally, it is robust when we use different performance measures, and robust when we take into account the lag-in-time effect of derivatives. Fourthly, this study separated our sample into firms with better performance and those with poorer performance. We find that the use of derivatives in poorer firms is the source of the negative effects, because derivatives investment has no significant influence on firms that have the better performance in the sample. This study considers the flawed nature of the Chinese derivatives market, and the fact that it is subject to severe controls. The scarcity of professionals employed in Chinese enterprises who are adept at investing in derivatives may be the main reason for the negative relationship.

The empirical results suggest that derivatives reduce the firm performance, which seems contrary to common beliefs. We conduct further tests to explore this issue by reexamining the relationship between derivative use and firm performance among the top-performing and the bottom-performing firms. The results show that the negative relation only significantly exists among bottom-performing firms but disappears among top-performing firms. Such results suggest that one possible reason for firms' failure to use derivatives successfully might be their lack of expertise and experience. Thus, it seems unlikely for poorly performed firms to improve their situation by adopting financial derivatives.

The structure of this study is as follows: Section 2 presents the literature review, Section 3 outlines the data description and the research methods, Section 4 contains the empirical analysis, and Section 5 makes conclusions.

2. Theoretical Foundation

Financial derivatives have been used by firms as an approach to deal with the financial risks associated with their business transactions, which are generated from unexpected changes in the market. Modigliani and Miller (1958) introduced the classic idea that shareholders can manage risk by themselves through diversifying their investments in a perfect market, where there is no asymmetry of information, no transaction costs, and no taxes and agency costs. This means that hedging at the corporate level is not related to a firm's value under such a situation. Similarly, in 2002, Warrant Buffet, the financial investment guru referred to financial derivatives as 'financial weapons of mass destruction, carrying dangers that, while now latent, are potentially lethal.' Such a statement suggests that, if not used properly, financial derivatives may even cause greater risks and reduce firm values, rather than reduce risk and add value to the firm.

Nevertheless, a tremendous number of enterprises do invest in financial derivatives in order to hedge the risks, which have resulted from frictions in the market. Thus, there is a need to investigate what factors contribute to firms' decisions to invest in financial derivatives and whether firms can benefit from their investment in derivatives.

2.1. Firms Characteristics and Use of Financial Derivatives

Prior research has identified certain firm characteristics as the factors at the firm level that can lead to derivative use. Based on a study of 720 large US companies, [Allayannis and Weston \(2001\)](#) found that companies are more likely to use foreign currency derivatives in order to manage risks if they have a larger size and greater leverage, profitability, investment growth as well as less financial constraints. Furthermore, empirical findings suggest that hedging through investing in financial derivatives is able to relieve underinvestment problems, when firms enjoy growth opportunities and when external financing is expensive ([Froot et al. 1993](#); [Jin and Jorion 2006](#)). In addition, tax liability is considered as a factor associated with derivative use. [Smith and Stulz \(1985\)](#) suggested that firms' hedging behavior may be prompted by tax incentives. When the after-tax incomes of firms demonstrate more convex functions, the expected taxes can be reduced by derivatives usage. Similarly, [Graham and Rogers \(2002\)](#) suggest that hedging through financial derivatives at a corporate level is associated with tax incentives, because derivative use can improve debt capacity and increase tax benefits.

The leverage ratio of the firm is also confirmed as an influencing factor ([Lau 2016](#)). Leverage ratio would affect a firm's performances, particularly when interest rates change, and thus it can influence a firm's decision whether to invest in financial derivatives as the hedging method. For companies with high leverage ratios, the great default risk is embedded in their fixed repayment obligations and their operational cash flow will encounter increasing volatility. Compared with firms with low operating leverage, firms with high leverage will have to endure growing expected costs associated with the possibility of bankruptcy, financial distress, and a reduced firm value. Hedging by using financial derivatives allows these firms to have more leverage on debt financing and to generate a greater firm value through saving on tax. This is because hedging by using derivatives can preserve internal cash flow and increase a firm's investment success, so that additional cash is generated from derivative use ([Carter et al. 2006](#)). In addition, costs associated with bankruptcy risk and potential financial distress can be reduced through hedging by investing in derivatives ([Arnold et al. 2014](#); [Smith and Stulz 1985](#)).

[Smith and Stulz \(1985\)](#) believe that companies, whose cash flow or income is greatly affected by foreign exchange risk, prefer to use derivatives. [Bartram et al. \(2009\)](#) examine the automobile industry and notes that the movement of the foreign exchange rate is a significant factor in derivative usage. The risk exposure from the movement of the foreign exchange rate, as one of three main risks (i.e., unexpected movement of interest rate, foreign exchange rate, and commodity prices) for companies, is highly associated with production cost, profits, and sales of firms.

Based on a sample of S&P 500 manufacturing firms from the Compustat database covering a period from 1993 to 2001, [Haushalter et al. \(2007\)](#) tested the hedging effect of cash holding. Findings from this study suggest that cash-holding and derivative use have a substitute relationship, as both cash-holding and hedging derivative use allow enterprises to minimize their need for external capital. Therefore, it is expected that there is a negative relationship between cash-holding and derivative use. Based on a differential effect between ambiguity and risk, [Friberg and Seiler \(2017\)](#) argue that higher ambiguity is associated with greater cash holdings, whereas more risk causes a higher probability of derivative use. Financial constraints are identified as a significant factor influencing firms' decision of whether to invest in derivatives as a means of hedging ([Froot et al. 1993](#)). When deadweight costs are included in the costs of external capital, the underinvestment problem will emerge as internal cash flow will be severely insufficient; hedging by using derivatives can generate extra cash flow that allows firms to circumvent the underinvestment problem ([Froot et al. 1993](#)).

[Smith and Stulz \(1985\)](#) believe that managers of companies with large stocks and risk aversion are more inclined to use derivatives for hedging. [Stulz \(1984\)](#) points out that, if the interests of management are mainly affected by the fluctuations of the company's value, and the cost of the company's use of derivatives is lower than the manager's own

safe-haven costs, then risk-averse managers will perform hedging. [Géczy et al. \(2007\)](#) find that information asymmetry, between a company's management and shareholders, can affect a company's hedging behavior.

In summary, prior research has identified firm characteristics in terms of firm size, return on assets, return on equity, R&D investment, CEO shareholding rate, leverage, cash holding, foreign exchange gain, and tax liability as the main factors that are likely to influence a firm's derivative use. Thus, these factors will be included in the empirical analysis as the explanatory variables to address the first question of this study.

2.2. Derivative Use and Firm Performance

As shown in the last section, various factors at a corporate level can lead to firms' investment in financial derivatives for hedging. However, research results are inconclusive regarding whether derivative use is associated with better performance or value of the firm. Based on a sample of 720 large firms for the period from 1990 to 1995, [Allayannis and Weston \(2001\)](#) examined the relationship between firm value and the use of foreign currency derivatives. Results from this study suggest that, on average, the market value of firms that used hedging derivatives was approximately 5% higher than the value of firms that do not use any hedging instruments. Similarly, another study by [Carter et al. \(2006\)](#) reported a higher hedging premium of approximately 10%.

On the other hand, based on a sample of derivative users of nonfinancial firms, [Guay and Kothari \(2003\)](#) found that derivative usage does not have a significantly positive influence on a firm's value, as the potential premium on hedging instruments is small compared to cash flows in equity value. Therefore, they suggest that the effect of derivative use is spurious, and that the slight change in premium is driven by other forms of risk management or that. Similarly, based on a sample of companies from the US oil and gas industry, [Jin and Jorion \(2006\)](#) found that there was no difference in market value between the firms that used hedging derivatives and those that did not. Furthermore, [Kim et al. \(2006\)](#) argue that the positive impact of using derivatives on firm value, as reported by [Allayannis and Weston \(2001\)](#), is difficult to interpret, because of issues such as changes in risk exposure throughout the sample, and endogeneity between firm value and hedging. Another empirical study based on US airline companies demonstrates that the premium generated from derivative use can be attributed to solving underinvestment ([Carter et al. 2006](#)). However, derivative use is not the only way to resolve the underinvestment problem. [Froot et al. \(1993\)](#) suggest that firms tend to choose underinvestment when they encounter significant distress. They further argue that underinvestment occurs when internal cash flow is low and the costs of external capital include deadweight costs are high. Thus, there is no consensus regarding whether hedging by using financial derivatives will solve this problem of underinvestment. On the other hand, it is clear that derivative use is not the only way for the firm to address the underinvestment problem. For example, cash-holding and cash equivalents could be regarded as a more direct method for firms to deal with underinvestment issue.

Based on a sample of firms from 39 countries, [Allayannis et al. \(2012\)](#) examined the interactive relationship between corporate governance, investment in foreign financial derivatives, and firm performance. Findings from this study suggest that they find that when companies have strong internal and external corporate governance, there will be a positive relationship between derivative use and firm performance ([Allayannis et al. 2012](#)). However, the results from this multi-national study regarding a positive link between derivative use and firm performance differ from those generated from single-country studies. For example, based on a sample of firms from France, [Khediri \(2010\)](#) found that when a firm increases its investment in financial derivatives, the value of the firm tends to reduce rather than increase, and that this reduction of firm value is caused by a lack of premium value being assigned to the firm's derivative use. Similarly, based on a firm sample from the Australian market, [Nguyen and Faff \(2010\)](#) found that when a firm makes investments in financial derivatives, the value of the firm tends to decrease. Thus,

although a large number of empirical studies have focused on the relationship between derivative use and firm performance, empirical results regarding this relationship still remain conflicting with each other.

A potential factor leading to the conflicting results regarding the relationship between derivative use and firm performance is the difference in industries based on which firm samples are drawn. Material supply chains and costs of primary goods output in some industries are exposed to significant volatility, leading to negative consequences on both sales and the cost of sales in these industries (Lau 2016). Therefore, when operating in these industries, firms are more likely to invest in financial derivatives as derivative use may lead to more consistent pricing on raw materials and thus avoid unnecessary losses. However, the particularities of specific industries may contribute to the bias in empirical findings regarding the relationship between derivative use and firm performance. For example, based on a sample of operating firms, Jin and Jorion (2006) found that firm value is not affected by derivative use. However, Carter et al. (2006) criticized that the results from Jin and Jorion's study may have been biased, given the fact that firms operating in investors in the US oil and gas industry tend to not invest in financial derivatives for the purpose of hedging.

The inconclusive empirical findings regarding the relationship between derivative use and firm performance leads to the second research question of whether firms would benefit from their investment in financial derivatives.

3. Research Design and Methodology

3.1. Sample Description

This study aims to answer two questions as: (1) what factors affect a firm's decision to use financial derivatives, and (2) whether derivative use of the firm leads to a positive effect on its performances. Data for this study were collected from China Securities Market and Accounting Research (CSMAR). The Shenzhen Stock Market was established in 1990. There are two stock exchange markets in China, and while the state-owned corporations were mainly listed on the Shanghai Stock Market, companies listed on the Shenzhen Stock Market were mostly privately-owned. Previous studies have suggested that firms that face large risk are more likely to use financial derivatives in their operations, and that financial derivative use tends to have a positive impact on a firm's value (Allayannis and Weston 2001; Carter et al. 2006). Compared with state-owned companies, privately-owned firms in China tend to suffer more severe financial constraints and face more financial difficulties in their operations, due to a lack of government support. Therefore, it is appropriate to sample for this study from the companies listed in Shenzhen Stock Market.

The sample of this study included 2529 firms listed on the Shenzhen Stock Exchange and the Growth Enterprise Market of China. Our unbalanced panel data consists of 8129 firm-year observations of derivative use and 12,177 firm-year observations for performance, covering an 11-year period from 2005 to 2015. In order to eliminate bias generated from the differences between industries, firms from all industries listed in the Shenzhen Stock Exchange have been included in this study, except for the financial industry. The reason for excluding firms in the financial industry is that firms in this industry may invest in financial derivatives for other reasons rather than hedging. Including financial firms may result in bias. Therefore, financial firms (e.g., banks, insurance, and investment companies), companies subject to Special treatment (ST), and Particular Transfer (PT) were excluded from the sample. Table 1 provides a description of the data.

Table 1. Data description (excluding financial firms).

Variable	N	Mean	SD	Min	P25	P50	P75	Max
Derivative_dummy	8129	0.0630	0.243	0	0	0	0	1
ROA	12,177	0.0410	0.0400	−0.0410	0.0140	0.0370	0.0670	0.125
ROE	12,177	0.0730	0.0690	−0.0790	0.0300	0.0700	0.113	0.213
Ln (Tobin's Q)	11,628	0.456	0.894	−2.739	−0.110	0.480	1.020	6.891

Table 1. Cont.

Variable	N	Mean	SD	Min	P25	P50	P75	Max
Tobin's Q	11,628	2.121	1.670	0.350	0.896	1.616	2.774	6.595
EBTA	12,151	0.408	0.300	0.0650	0.190	0.324	0.529	1.207
Leverage	12,177	0.428	0.213	0.0910	0.248	0.420	0.603	0.802
Net Profit Margin	12,158	0.154	7.507	−277.9	0.0230	0.0670	0.141	715.1
Assets Turnover	12,177	0.600	0.387	0.144	0.313	0.498	0.770	1.600
Size	12,177	21.92	1.331	14.94	21.00	21.75	22.64	28.51
Operating Cash Flow	12,158	0.0700	0.149	−0.267	−0.00200	0.0690	0.155	0.368
CEO_TS	11,841	0.138	0.212	0	0	0.00100	0.256	0.897
Z	11,627	0.618	0.383	0.162	0.333	0.518	0.785	1.603
Cash Holding	12,152	0.423	0.421	0.0430	0.130	0.260	0.554	1.616
Capital Expenditure	12,158	0.123	0.131	0.00400	0.0290	0.0740	0.164	0.492

This table reports the information obtained from the sample, which has been collected from the CSMAR from 2005 to 2015. This sample covers 8129 derivative observations and 12,177 firm performance observations in the Shenzhen Stock Exchange and the Growth Enterprise Market (GEM). In this table, ROA is return on assets; ROE is return on equity; Tobin's Q, is adopted to measure a firm's market value at the stock exchange market, Ln(Tobin's Q) is the natural logarithm of Tobin's Q; EBTA is earnings before interests and tax scaled by total assets; Leverage is the leverage ratio which is calculated by dividing debt by size; Net Profit Margin is profit over sales, to capture the effects of profitability on firms' performance; Assets Turnover is calculated by sales over book value of total assets; Size is the natural logarithm of a firm's total assets. Operating Cash Flow is the firm's cash flow scaled by total assets; CEO_TS is the stockholding ratio of CEO of the firm; Z is the Altman Z-score, which measures the bankruptcy risk of the firm; Cash Holding is cash and cash equivalents scaled by total assets; Capital Expenditure is the ratio of capital expenditure over total assets.

To eliminate the impact of the industry, our regression model controlled the variable of the industry. This variable was denoted by the industry code developed by China Securities Regulatory Commission (CSRC). When operationalizing the variable in the study, we kept the original CSRC codes for the primary classification of the industries (i.e., the first letter of the CSRC industry codes for industries was retained) except the manufacturing industry. As shown in Table 2, over 60% of the companies in the sample came from the single industry of manufacturing, and this more severe outlier in terms of the industry could generate bias in model estimations. Thus, firms in the manufacturing industry required a secondary classification.

Table 2. Industrial distribution of the sample (excluding the financial industry) ¹.

Industry	Frequency	Percentage	Cumulation
A	39	1.54	1.54
B	67	2.65	4.19
C	1629	64.41	68.6
D	85	3.36	71.97
E	64	2.53	74.5
F	151	5.97	80.47
G	83	3.28	83.75
H	10	0.4	84.14
I	139	5.5	89.64
K	132	5.22	94.86
L	27	1.07	95.93
M	18	0.71	96.64
N	24	0.95	97.59
O	3	0.12	97.71
P	1	0.04	97.75
Q	3	0.12	97.86
R	29	1.15	99.01
S	25	0.99	100
Total	2,529	100	

¹ This table shows the industry distribution of all 2529 firms in the sample. The first column shows the CSMAR industry code. The manufacturing industry, which is represented by C, occupies 64.41% of the total sample. Therefore, the firms in the manufacturing industry have secondary classification codes.

Based on the difference in ownership, the firms included in the sample can be divided into two groups of privately-owned and state-owned companies. In comparison with state-owned companies, private firms are more likely to use derivatives to hedge against financial risks. State-owned companies are significantly different from private firms along the dimension of objectives, resource endowment, operational risks, and government intervention (Yang et al. 2017). With the support from the Chinese government, state-owned firms have easier access to financial and credit approval than their privately-owned counterparts. With the encouragement from the Chinese government, banks provide more financial support to state-owned firms, even though some of them have lower productivity than privately-owned enterprises, resulting in low efficient capital investment by state-owned companies (Chang and Boontham 2017; Song et al. 2011). Even over 30 years after the reform and opening-up of the Chinese economic policies, there has been still a bias against privately-owned firms in markets and banks, such as charging higher interest rates and imposing harsher conditions (Yang et al. 2017). Therefore, private firms rely more on their internal funds, such as cash and cash equivalents, than state-owned companies, and have more incentives to use derivatives in order to stabilize their cash flows.

Table 3 demonstrates the differences in characteristics between firms that use and those that do not use derivatives. The differences between users and non-users of derivatives leads us to the first research question of the study: which factors lead to the use of derivatives by Chinese firms? Moreover, observing the performance indicators (measured as ROA, ROE, and Tobin's Q) as shown in Table 3, non-users of derivatives have slightly outperformed derivative users. This observation suggests that it is uncertain whether derivative use has a positive effect on firm performance. Therefore, we have the second research question of this study: do firms truly benefit from their derivative use?

Table 3. The description of derivative-using firms and non-derivative-using firms. ¹

Panel A								
Variables	N	Mean	SD	Derivative_dummy= 0		P50	P75	Max
				Min	P25			
Derivative_dummy	7618	0	0	0	0	0	0	0
ROA	7049	0.0450	0.0400	−0.0410	0.0170	0.0420	0.0710	0.125
ROE	7049	0.0720	0.0660	−0.0790	0.0310	0.0690	0.109	0.213
Ln (Tobin's Q)	6697	0.627	0.829	−2.182	0.137	0.635	1.150	6.891
Tobin's Q	6697	2.375	1.678	0.350	1.147	1.886	3.158	6.595
Growth	7031	0.392	0.280	0.0650	0.195	0.319	0.498	1.207
Leverage	7049	0.377	0.207	0.0910	0.200	0.350	0.534	0.802
Net Profit Margin	7037	0.237	8.859	−58.38	0.0310	0.0830	0.160	715.1
Asset Turnover	7049	0.564	0.362	0.144	0.304	0.470	0.708	1.600
Size	7049	21.56	1.089	14.94	20.83	21.44	22.14	26.07
Operating Cash Flow	7037	0.0700	0.149	−0.267	−0.00400	0.0710	0.157	0.368
CEO_TS	6975	0.197	0.232	0	0	0.0590	0.399	0.897
Z	6697	0.584	0.357	0.162	0.327	0.491	0.728	1.603
Cash Holding	7034	0.490	0.458	0.0430	0.149	0.316	0.675	1.616
Capital Expenditure	7037	0.137	0.137	0.00400	0.0370	0.0870	0.185	0.492
Panel B								
Variables	N	Mean	SD	Derivatives_dummy = 1		P50	P75	Max
				Min	P25			
Derivatives_dummy	511	1	0	1	1	1	1	1
ROA	476	0.0400	0.0380	−0.0410	0.0140	0.0360	0.0620	0.125
ROE	476	0.0740	0.0680	−0.0790	0.0320	0.0650	0.115	0.213
Ln (Tobin's Q)	454	0.306	0.826	−2.489	−0.178	0.366	0.860	2.829
Tobin's Q	454	1.816	1.396	0.350	0.837	1.442	2.364	6.595
EBTA	475	0.283	0.216	0.0650	0.146	0.220	0.342	1.207
Leverage	476	0.443	0.209	0.0910	0.274	0.442	0.615	0.802
Net Profit Margin	475	0.0590	0.0820	−0.443	0.0170	0.0410	0.0850	0.601
Asset Turnover	476	0.788	0.409	0.144	0.455	0.759	1.034	1.600
Size	476	22.21	1.340	19.63	21.19	21.97	22.86	27.14
Operating Cash Flow	475	0.0640	0.116	−0.267	0.0120	0.0640	0.124	0.368
CEO_TS	474	0.153	0.222	0	0	0.0190	0.260	0.775
Z	454	0.804	0.403	0.162	0.474	0.780	1.047	1.603
Cash Holding	474	0.264	0.310	0.0430	0.0710	0.156	0.305	1.616
Capital Expenditure	475	0.103	0.112	0.00400	0.0290	0.0620	0.136	0.492

¹ Panel A presents the information regarding derivative non-users and Panel B presents the information regarding derivative users. The firm performance of derivative non-users (the median value of ROA, ROE, Ln (Tobin's Q), and Tobin's Q) is slightly better than that of derivative users.

3.2. Estimation Models

Our empirical estimations were based on the dataset of the unbalanced panel data. In comparison to other types of data such as time-series data and cross-sectional data, the panel data type of longitudinal data has unique advantages, including its ability to detect and measure statistical effects that either pure time series or cross-sectional data cannot, as well as the ability to minimize estimation biases that may arise from aggregating time series groups into a single time series. However, when using panel data for estimation, some potential problems need to be addressed. First, there is a probability that the variables from different firms in the data are not independent. Second, when the estimations involve a large number of parameters, standard regression methods could become ill-posed. Our study addressed the issue of potential correlations among the sampled firms. We performed regression analysis clustered by firms. To meet the independent and identical distribution, we allowed for correlation among residuals with groups, but rejected the presence of correlation between different groups.

An alternative modeling method is linear stochastic approximations. Stochastic approximation methods are a family of iterative methods typically used for root-finding problems or for optimization problems. The recursive update rules of stochastic approximation methods can be used for solving linear systems when the collected data is corrupted by noise, or for approximating extreme values of the function, which cannot be computed directly by only estimated via noisy observations (Kouritzin 1996; Nemirovski et al. 2009; Toulis and Airolidi 2015). A major advantage of linear stochastic approximation methods lies in the fact that they can facilitate estimation with a large amount of data, in which model parameters are updated sequentially using small batches of data at each step (Toulis and Airolidi 2015).

3.2.1. Estimation Model for Firm Characteristics and Derivative Use

Based on our review of previous studies in the last section regarding firm characteristics and derivative use, we developed the following model to examine factors that lead to derivative use by Chinese firms:

$$\begin{aligned} \text{Derivatives_dummy}_{it} &= \beta_0 + \beta_1 \ln(\text{size}_{i,t}) + \beta_2 \text{OPERCF_a}_{i,t} + \beta_3 \text{Leverage}_{i,t} + \beta_4 \text{ExGain}_{i,t} \\ &+ \beta_5 \text{Oprevenuegrowth}_{i,t} + \beta_6 \text{CEO_TS}_{i,t} + \beta_7 \text{RD_dummy}_{i,t} + \beta_8 \text{Z}_{i,t} + \beta_9 \text{Dep_a}_{i,t} \\ &+ \beta_{10} \text{ROA}_{i,t} + \beta_{11} \text{ROE}_{i,t} + \beta_{12} \text{Tobin's } Q_{i,t} + \varepsilon, \end{aligned} \quad (1)$$

$$\begin{aligned} \text{Derivatives_dummy}_{it} &= \beta_0 + \beta_1 \ln(\text{size}_{i,t}) + \beta_2 \text{OPERCF_a}_{i,t} + \beta_3 \text{Leverage}_{i,t} + \beta_4 \text{ExGain}_{i,t} \\ &+ \beta_5 \text{Oprevenuegrowth}_{i,t} + \beta_6 \text{CEO_TS}_{i,t} + \beta_7 \text{RD_dummy}_{i,t} + \beta_8 \text{Z}_{i,t} + \beta_9 \text{Dep_a}_{i,t} \\ &+ \beta_{10} \text{ROA}_{i,t} + \beta_{11} \text{ROE}_{i,t} + \beta_{12} \text{Tobin's } Q_{i,t} + \beta_{13} \text{SOE}_i + \varepsilon, \end{aligned} \quad (2)$$

where $\text{Derivatives_dummy}_{it}$ as the dependent variable equals 1, if firm i uses derivatives at time t , otherwise it equals 0. Equation (1) provides a baseline model to examine the relationship between firm characteristics and derivative use. Equation (2) adds firm ownership (SOE) to examine the effect of the firm's ownership structure on derivative use. In either Equations (1) or (2), ε represents the idiosyncratic error term at time t .

The explanatory variables are included as:

- (1) $\ln(\text{size}_{i,t})$ is the size level of a firm i at time t .
- (2) $\text{OPERCF_a}_{i,t}$ is the operational cash flow of a firm i at time t .
- (3) $\text{Leverage}_{i,t}$ is the leverage ratio which is calculated by dividing debt by size.
- (4) $\text{ExGain}_{i,t}$ indicates the exchange gains of firm i at time t .
- (5) $\text{Oprevenuegrowth}_{i,t}$ is the growth rate of the operational revenue of a firm i at time t .
- (6) $\text{CEO_TS}_{i,t}$ is the stockholding ratio of CEO of the firm i at time t .

- (7) $RD_dummy_{i,t}$ is a dummy variable to judge if firm i has made research and development investment at time t .
- (8) $Z_{i,t}$ is the Altman Z-score, which measures the bankruptcy risk of firm i at time t .
- (9) $Dep_a_{i,t}$ measures the tax shield of firm i at time t .
- (10)–(12) Three variables represent the performance of the firm, measured by ROA, ROE and Tobin's Q, respectively.
- (13) SOE_i is the dummy variable to analyze ownership of the firms, which equals to 0 if the observation is a private enterprise, and it equals to 1 if the observation is a state-owned enterprise.

The Logit model was selected to estimate Equations (1) and (2), as the dependent variable of derivative use is a binary-choice dummy. The Logit model is a widely used analytical method for binary-choice estimation. In comparison to the Probit model, it provides an unambiguous and concise setting on result explanation, because the cumulative distribution function in logistic distribution specifies an analytical expression while the standard distribution in the Probit model does not (Wooldridge 2010). As shown in Table 3 (Panels A and B), data for firms' derivative use are highly unbalanced, with an overwhelming majority of firms reported as non-derivative users. If untreated, empirical estimation may suffer from potential event bias. Following (King and Zeng 2001), we applied the bias-corrected estimations in our regression analysis so that empirical results would not be biased from the unbalanced distribution of the derivative use as the dummy variable.

As shown in the Results section, four model specifications were performed. Model (1) is the benchmark regression used to test the common phenomenon. Model (2) adds two fixed variables (*industry* and *Year*) in order to control the effects of industry and time. In Model (3), the full sample is split into two groups of state-owned and privately-owned firms by adding the variable of SOE to examine. The differences between these two types of firms in terms of their derivative use. Based on Model (3), Model (4) controls the effects of industry and time.

3.2.2. Estimation Model for Derivative Use and Firm Performance

In order to examine the relationship between derivative use and firm performance, Models (3) and (4) were developed, and three variables were adopted as the measures of firm performance. Following previous studies (Bartram et al. 2011; Jin and Jorion 2006), Tobin's Q, is adopted to measure a firm's market value at the stock exchange market, and it is a proxy of firm performance in Model (3). By measuring the market value created over the book value, Tobin's Q helps to produce market values comparable across sample firms and mitigates any scale effects. Following previous research (Choi et al. 2013; Gay et al. 2011), Model (4) uses Return on Assets (ROA) and Return on Equity (ROE) as indicators for firm performance, were introduced in this study.

$$\text{Tobin's } Q_{i,t} = \beta_0 + \beta_1 * \text{Derivatives_dummy}_{i,t} + \sum_K \beta_K * \text{CONTROL}_{i,t}^K + \varepsilon, \quad (3)$$

$$\text{Tobin's } Q = \frac{((\text{Total shares Outstanding} - \text{Bshares Outstanding}) * P_A + \text{BShares Outstanding} * P_b * \text{exchange rate})}{(\text{Total Assets})}$$

$$\text{Firm performance}_{i,t} = \beta_0 + \beta_1 * \text{Derivatives_dummy}_{i,t} + \beta_2 * \text{Derivatives_dummy}_{i,t} * \text{SOE}_i + \sum_K \beta_K * \text{CONTROL}_{i,t}^K + \varepsilon. \quad (4)$$

In Models (3) and (4), derivative use is the independent variable. In Model (4), $\text{Derivatives_dummy}_{i,t} * \text{SOE}_i$ is included to measure the different effects between private and state-owned companies. The control variables and their definitions are shown in Table 4.

Table 4. Description of control variables.

Control Variable	Definition
SOE	The dummy of a firm's nature from CSMAR, which equals to 0 if the firm is privately-owned and equals to 1 if the firm is state-owned. It is used to control the effects of a firm's ownership structure.
Size	The Napierian Logarithm of a firm's total assets, to control the relationship between a firm's size and its performance
Operating Cash Flow	Using a firm's cash flow scaled by total assets to control the relationship between a firm's operations and its performance
Depreciation	Depreciation scaled by total assets to establish the effects of tax shields on a firm's performance
CEO_TS	The ratio of shareholding by a CEO is introduced to control the potential relationship between agent costs and a firm's performance
RD_dummy	Is used to judge whether companies invest in research and development to control the underinvestment problem and firm performance
Z	The Altman Z-score is used to control the influences of bankruptcy costs on a firm's performance. This variable is calculated by the formula: $Z = 0.012 * X_1 + 0.014 * X_2 + 0.033 * X_3 + 0.006 * X_4 + 0.999 * X_5$, where, X_1 = (liquid asset-liquid debt)/total assets; X_2 = retained earnings/total assets; X_3 = EBIT/total assets; X_4 = market value of common shares and preferred stock/total debt; X_5 = total sales/total assets
Leverage	The leverage ratio is calculated by total debt over total assets, to establish the relationship between capital structure and a firm's performance
Exchange Gain	Exchange gain scaled by total assets is used to control the impacts of movements of foreign exchange rates on a firm's performance

Following [Lau \(2016\)](#), pooled Ordinary Least Square (OLS) regression model was adopted to empirically examine the effect of derivative use on firm performance. In pooled OLS model, clustering by each firm can cut out the potential interactions among individual firms and thus generate the independence of probability. Before performing a dynamic panel data analysis, three statistical issues need special treatment. First, firm-specific, time-specific, and industry-specific effects in the dataset may have potential implications in empirical estimations, because the residuals of a given firm, a given year, or a given industry may be correlated across years or firms (i.e., time-series dependence and cross-sectional dependence). Second, the choice between fixed-effects and random-effects model specifications needs to be made. Third, although this paper focuses only on the use of financial derivatives with the purpose of hedging, the relationship between derivative use and its explanatory variables may not be clear-cut. As the nature of hedging by using derivatives is a type of investment, the reverse causality may arise with the feedback effects between firm profitability and corporate hedging capacity.

Several diagnostic tests were performed to address these three statistical issues. First, the Hausman test was performed, and the results suggest that the idiosyncrasies in the cross-section data need to be fixed, and thus the fixed-effects model was adopted for model estimation. Second, time-effects and industry-effects were also controlled in the model estimation, and the results are reported following benchmark regressions in the respective tables of results. Third and more importantly, robust standard error estimations with a fixed-effects model were performed to control the potential problems with the endogeneity in the data. Prior research suggests that robust standard error estimations (FE-SE or RE-SE) in either fixed-effects or random-effects model are found to be unbiased due to the permanent firm-effect ([Abadie et al. 2017](#); [Cameron and Miller 2015](#); [Petersen 2009](#)). Thus, the potential problem of endogeneity was effectively addressed.

As shown in Results section, four model specifications of the pooled OLS estimation were performed for each of the three performance measures respectively (ROA, Tobin's Q, and ROE). The first one is a benchmark regression, including all the control variables except the variable of SOE. The second regression model controlled the effects of time and industry. The third regression (Model 4) added $\text{Derivatives_dummy}_{i,t} * \text{SOE}_i$ and the

control variable of SOE. Based on regression three, the fourth regression controlled the effects of time and industry.

4. Empirical Results and Discussion

4.1. Firm Characteristics and Derivative use

Table 5 demonstrates the empirical results regarding the factors that influence companies' decisions on whether to use financial derivatives. Six variables of firm size, operational cash flow, tax shield (measured as depreciation divided by total assets), R&D investment, bankruptcy possibility (represented by Z-score), and Tobin's Q, are significant across all four model specifications. As shown in the specifications of Models 3 and 4, ROA is significant after controlling the variable of firm ownership. However, the variable of firm ownership is insignificant after controlling the effects of time and industry.

Table 5. Factors that impact a firms' decision to use derivatives ¹.

	(1)	(2)	(3)	(4)
	Derivatives_dummy	Derivatives_dummy	Derivatives_dummy	Derivatives_dummy
SOE			−0.366 **	−0.186
			−2.14	−1.05
Ln(size)	0.441 ***	0.491 ***	0.440 ***	0.489 ***
	9.02	8.18	9.04	8.20
Cash Flow	1.734 **	1.504 *	1.708 **	1.485 *
	2.33	1.83	2.29	1.81
Depreciation	−0.572	−1.027 *	−0.532	−1.042 *
	−1.18	−1.66	−1.10	−1.69
CEO_TS	0.185	0.003	0.237	0.031
	0.73	0.01	0.92	0.11
RD_dummy	0.944 ***	0.469 ***	0.937 ***	0.473 ***
	7.37	2.92	7.30	2.94
Z	0.547 ***	0.596 ***	0.543 ***	0.595 ***
	9.88	8.34	9.82	8.35
Leverage	−0.074	0.008	−0.054	0.014
	−0.27	0.04	−0.21	0.08
Exchange Gain	−0.000	−0.000	−0.000	−0.000
	−0.19	−0.70	−0.21	−0.70
Growth	−0.001	−0.001	−0.001	−0.001
	−0.54	−0.51	−0.59	−0.53
ROE	1.039 *	0.875	1.048 *	0.882
	1.71	1.39	1.73	1.41
ROA	−4.136 **	−2.735	−4.105 **	−2.755 *
	−2.54	−1.64	−2.54	−1.68
Tobin's Q	−0.093 ***	−0.144 ***	−0.095 ***	−0.145 ***
	−2.73	−3.14	−2.78	−3.16
Fixed Effects	NO	Yes	NO	Yes
N	8387	7715	8387	7715

¹ This table shows the factors that may affect firms' decisions regarding hedging using derivatives. These factors are: firm size, operating cash flow, tax shield (represented by depreciation divided by total assets), research and development investment, possibility of bankruptcy (represented by Z-score), ROA, and Tobin's Q. After controlling the effects of time and industry, the nature of a firm is not a deciding factor of derivative usage. *t*-statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The significant effect of firm size suggests that larger companies are more likely to invest in financial derivatives. Two factors may contribute to this result. First, larger firms have a higher level of risk exposure in comparison to smaller firms, due to their more extensive operations. Second, larger firms are financially more capable of performing complex derivative operations by hiring professional managers. Firms with more cash flow are more likely to use derivatives, as these firms have a stronger need to stabilize their daily operations against the financial risks from the uncertainty associated with unexpected changes of exchange and interest rates. A higher R&D level indicates that

the firms have more investment opportunities. As a result, these firms are more likely to engage in derivative use to safeguard the R&D investment. A lower Altman Z-score means a firm has a larger probability of bankruptcy. Therefore, a positive relationship between a Z-score and the derivative usage dummy indicates that firms with lower bankruptcy risk are more likely to use derivatives. The negative impact of tax shields (represented by depreciation to total assets) on a firm's derivative use indicates that companies that enjoy more tax benefits tend to reduce their derivative investment.

When it comes to the influence of a firm's performance variables, the negative relationships between derivative use and ROA, as well as between derivative use and Tobin's Q, support the suggestion that firms in the Chinese market tend to invest in financial derivatives with the purpose to improve firm performance.

4.2. Derivative Use and Firm Performance

In this section, we address the issue of whether the investment in financial derivatives can result in improvement of the firm performance. Here, firm performance is measured by the three indicators of ROA, ROE, and Tobin's Q.

Table 6 demonstrates the effect of derivative use on ROA as one measure of firm performance. As shown in Table 6, four model specifications are performed. Model 1 is the benchmark model. Based on Model 1, Model 2 adds two control variables of time and industry. Model 3 tests derivative use on ROA in terms of the two different firm groups (state-owned and private firms) by adding the dummy variable SOE. Based on Model 3, Model 4 adds two control variables of time and industry. Some control variables are automatically removed by Stata due to multicollinearity.

Table 6. The effects of derivative use on ROA ¹.

	(1)	(2)	(3)	(4)
	ROA	ROA	ROA	ROA
Derivative_dummy	−0.007 *** (−4.39)	−0.006 *** (−3.39)	−0.012 ** (−2.09)	−0.008 (−1.56)
Derivative_dummy *SOE			0.005 (0.80)	0.003 (0.53)
SOE	0.002 (1.53)	0.002 (1.13)	0.002 (1.24)	0.002 (0.93)
Size	0.007 *** (16.29)	0.008 *** (19.07)	0.007 *** (16.28)	0.008 *** (19.05)
Asset Turnover	0.023 *** (19.90)	0.031 *** (24.40)	0.023 *** (19.89)	0.031 *** (24.39)
Net Profit Margin	0.000 *** (4.46)	0.000 *** (5.04)	0.000 *** (4.45)	0.000 *** (5.03)
Leverage	−0.107 *** (−46.18)	−0.105 *** (−43.90)	−0.107 *** (−46.16)	−0.105 *** (−43.89)
Fixed Effects	NO	Yes	NO	Yes
N	7512	7512	7512	7512
R2	0.238	0.315	0.239	0.315
Adjust R2	0.238	0.310	0.238	0.310

¹ In this table, four regressions are introduced. The first column is the benchmark regression of model (3). The second column is based on the first regression but controls the effects of time and industry. The third column is the benchmark regression of model (4). The fourth column is based on the third regression but controls the effects of time and industry. This table shows that using derivatives has negative effects on ROA, and that the nature of a company has no impact on the outcomes of using derivatives. Some variables included are automatically removed by Stata due to multicollinearity. *t*-statistics in parentheses ** *p* < 0.05, *** *p* < 0.01.

The results shown in Table 6 suggest that derivative use negatively affects ROA (Model 1), although the negative impact is slightly reduced when the effects of time and industry are controlled in Model 2. Results from Model 3 demonstrates that private enterprises are more seriously exposed to the negative effects of using derivatives (−0.014), while state-owned companies also suffer from these negative effects of derivative use, but

the magnitude is less severe in comparison to that of the private firms. The reason for the difference most likely lies in the fact that state-owned companies have better access to significant financial support from the Chinese government. Financial support from the government can lead to increased profitability and investor confidence, thus partly offsetting the negative effects of using derivatives, such as the negative return of derivatives and the loss of effectiveness when risks erupt in the whole market (e.g., when the stock market crashed in 2015).

In order to further examine the relationship between derivative use and firm performance, we replaced the performance measure of ROA with another two performance indicators of Tobin's Q and ROE. Table 7 presents the model results with Tobin's Q as the performance measure. Similar to the case in Table 6, we performed four model specifications. As shown in Table 7, derivative use has a significant but negative effect on the dependent variable of Tobin's both in Models 2 and 4. These results confirmed the negative effect of derivative use on firm performance. Further, this negative effect is consistent across both state-owned and private firms.

Table 7. The effects of derivative use on Tobin's Q¹.

	(1)	(2)	(3)	(4)
	Tobin's Q	Tobin's Q	Tobin's Q	Tobin's Q
Derivative_dummy	−0.033 (−1.06)	−0.079 *** (−3.29)	−0.193 * (−1.94)	−0.163 ** (−2.17)
Derivative_dummy *SOE			0.176 * (1.70)	0.093 (1.19)
SOE	−0.030 (−1.03)	−0.002 (−0.11)	−0.045 (−1.48)	−0.011 (−0.46)
Size	−0.312 *** (−39.07)	−0.364 *** (−57.01)	−0.312 *** (−39.10)	−0.364 *** (−57.03)
Asset Turnover	0.012 (0.60)	0.175 *** (9.50)	0.012 (0.58)	0.175 *** (9.48)
Net profit margin	0.004 *** (4.12)	0.004 *** (5.41)	0.004 *** (4.09)	0.004 *** (5.40)
Leverage	−1.327 *** (−31.06)	−1.083 *** (−31.12)	−1.326 *** (−31.04)	−1.083 *** (−31.11)
Fixed Effects	NO	Yes	NO	Yes
N	7140	7140	7140	7140
R ²	0.439	0.685	0.439	0.685
Adjust R ²	0.438	0.683	0.438	0.683

¹ In this table, four regressions are introduced. The first column is the benchmark regression of model (3). The second column is based on the first regression but controls the effects of time and industry. The third column is the benchmark regression of model (4). The fourth column is based on the third regression but controls the effects of time and industry. This table shows that using derivatives brings negative effects on Tobin's Q and that the nature of a company has no impact on the outcomes of using derivatives, after controlling the effects of time and industry. *t*-statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The same procedure of four model specifications is performed after adopting ROE as the measure of firm performance. The results are presented in Table 8. The regression results are qualitative, similar as with the case of using ROA and Tobin's Q as measures of firm performance. Thus, the negative effect of derivative use on firm performance is further confirmed.

Table 8. The effects of derivative use on ROE ¹.

	(1)	(2)	(3)	(4)
	ROE	ROE	ROE	ROE
Derivative_dummy	−0.010 *** (−3.14)	−0.006 * (−1.95)	−0.016 (−1.57)	−0.010 (−1.00)
Derivative_dummy *SOE			0.007 (0.65)	0.004 (0.42)
SOE	0.004 (1.39)	0.003 (1.12)	0.003 (1.14)	0.003 (0.95)
Size	0.012 *** (15.83)	0.014 *** (18.45)	0.012 *** (15.81)	0.014 *** (18.44)
Asset Turnover	0.037 *** (17.95)	0.054 *** (23.66)	0.037 *** (17.94)	0.054 *** (23.65)
Net Profit Margin	0.000 *** (4.62)	0.000 *** (5.18)	0.000 *** (4.61)	0.000 *** (5.17)
Leverage	−0.065 *** (−15.60)	−0.067 *** (−15.52)	−0.065 *** (−15.59)	−0.067 *** (−15.52)
Control Year and industry	NO	Yes	NO	Yes
N	7512	7512	7512	7512
R2	0.073	0.175	0.073	0.175
Adjust R2	0.072	0.169	0.072	0.169

¹ In this table, four regressions are introduced. The first column is the benchmark regression of model (3). The second column is based on the first regression but controls the effects of time and industry. The third column is the benchmark regression of model (4). The fourth column is based on the third regression but controls the effects of time and industry. This table shows that using derivatives has negative effects on ROE, and that the nature of a company has no impact on the outcomes of using derivatives. *t*-statistics in parentheses * $p < 0.1$, *** $p < 0.01$.

In summary, derivative use tends to exert a negative effect on firm performance as measured by indicators of ROA, ROE, and Tobin's Q. This means that using derivatives reduces a company's performance. Two factors may be associated with the negative effects of derivative use on firm performance in the context of firms from China. First, compared with developed markets, the market of financial derivatives in China is flawed and suffers from tight control of government agencies. Insufficient hedging instruments mean that Chinese firms often fail to manage the risks through using derivatives. Moreover, the intervening actions were taken by various government agencies such as China Securities Regulatory Commission (CSRC) after the stock market crashed in 2015 led to a high level of difficulty for Chinese firms to invest in derivatives, and thus it is impractical for Chinese firms to use investment in financial derivatives as an effective method when managing business risks. Second, there is a severe lack of skills and expertise in Chinese firms in relation to business transactions for investment in financial derivatives. Investments in financial derivatives made by inexperienced operators contribute to the risks of corporations and reduce their performance.

It takes time for the derivative use to generate influence on firm performance, especially when firms just initiated derivative use first time. In order to consider the time effect of derivative use, we examined the relationship between derivative use and firm performance by taking a time lag of one year. For this analysis, firm performance is measured by the three financial indicators of ROA, ROE, and Tobin's Q, respectively. Table 9 shows the effect of derivative use in the past on the firm performance in the current period. The first column for each performance indicator presents the results of the benchmark regression, and the results of the second column have controlled time and industry effects. As shown in Table 9, derivative use has a significant and negative effect on both ROA and ROE as the measures of firm performance, and these negative effects remain when the time lag effect has been controlled. On the other hand, derivative use has no significant effect on firm performance when performance is measured by Tobin's Q.

Table 9. The lagged effects of derivative use on firm performance ¹.

	ROA	ROA	ROE	ROE	TQ	TQ
Lag(Derivative_dummy) ₋₁	−0.08 *** (−3.99)	−0.008 *** (−3.95)	−0.013 *** (−3.64)	−0.011 *** (−3.27)	−0.037 (−0.55)	−0.039 (−0.63)
SOE	−0.002 (−1.02)	−0.002 (1.29)	−0.000 (−0.03)	−0.001 (−0.38)	−0.071 (−1.26)	−0.054 (−1.04)
Size	−0.002 *** (−5.42)	−0.001 *** (−3.97)	0.006 *** (9.61)	0.007 *** (11.46)	−0.660 *** (−52.03)	−0.694 *** (−59.28)
Asset Turnover	0.013 *** (12.79)	0.013 *** (12.45)	0.037 *** (19.78)	0.034 *** (18.72)	−0.305 *** (−8.55)	−0.245 *** (−7.48)
Net Profit Margin	0.000 * (1.68)	0.000 ** (2.05)	−0.000 * (−1.67)	−0.000 (−1.40)	0.000 (0.20)	0.001 (0.92)
Fixed Effects	NO	YES	NO	YES	NO	YES
N	11,429	11,429	11,429	11,429	10,788	10,788
R2	0.0175	0.0378	0.0426	0.0624	0.2140	0.3488
Adjust R2	0.0171	0.0367	0.0422	0.0613	0.2136	0.3480

¹ In this table, three different indicators of firm performance (ROA, ROE, and Tobin's Q) are used to test the lagged effects of using derivatives. For each indicator, the first column is the benchmark regression. The second column is based on the first regression, but the effects of time and industry are controlled. This table shows that derivative usage on forwarding time has a significantly negative influence on ROA and ROE, but no significant impact on firm value. *t*-statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9 demonstrates the negative effect of using derivatives in the past on the firm's current performance. This negative effect with time lag is consistent with the results from the empirical analyses in the last section. Two factors may explain this negative effect even with lagged time effect being controlled. Firstly, the ineffectual operation of investment in financial derivatives may increase the risk exposure of companies and then damage the firm's performance. Secondly, investment in hedging is not free. Usually, hedging by derivatives sacrifices returns as a prerequisite. Therefore, when firms increase investment in financial derivatives, investing firms will expect firm performance to decline in the future to some extent. The lack of impact on firm value (presented by Tobin's Q) may be due to derivative use only affecting the value of the firm during the current period. However, in the subsequent time periods, internal factors can have more obvious effects on firm value rather than just derivative investment.

4.3. Further Empirical Analysis

Results generated from our examination of the first research question (what type of firms are more likely to invest in financial derivatives) suggest that firms with poorer performance are more likely to invest in derivatives. However, results from our examination of the second research question (the relationship between derivative use and firm performance) demonstrate that derivative use tends to reduce, rather than improve, firm performance. To examine these seemingly contradictory empirical results, we conducted the further empirical analysis.

To conduct this further analysis, we split the full sample of firms into sub-samples. First, based on differences in terms of ROA among the sampled firms, we split the full sample into two sub-samples, and they are the firms with a ROA value higher and lower than the median value of the full sample. Second, based on differences in terms of ROE among the sampled firms, we also split the full sample into two sub-samples of firms with a ROE value higher and lower than the median value of the full sample, respectively. Then, we introduced the performance indicator Tobin's Q as the dependent variable to examine the relationship between derivative use and firm performance. The expected result is that derivative use will lead to a reduction of performance for those firms whose operations are less successful.

For this further regression analysis of the relationship between derivative use and firm performance, we adopted the conceptual model developed by Carter et al. (2006).

The model is provided below. All the control variables included in the model are listed in Table 10.

$$\text{Tobin's } Q = \text{Derivative_dummy}_{i,t} + \sum_K \beta_K * \text{CONTROL}_{i,t}^K + \varepsilon. \quad (5)$$

Table 10. The control variables for the further test.

Control Variables	Definition
Size _{i,t}	The Napierian Logarithm of a firm's total assets, to control the relationship between a firm's size and its performance
Dividend_dummy _{i,t}	Dividend payout dummy: if the observation pays dividends on time <i>i</i> , the variable is equal to 1, otherwise it is equal to 0.
CapitalExpenditure_a _{i,t}	The ratio of capital expenditure over total assets, which controls the effects of growth opportunities.
CF_a _{i,t}	Using a firm's cash flow, scaled by total assets, to control the relationship between a firm's operations and its performance
Cash_s _{i,t}	The ratio of cash to sales, to control the influences of liquidity.
CEO_TS _{i,t}	CEO options-to-shares outstanding, to control the potential relationship between agent costs and a firm's performance
Year	To control the effects of time
Industry	To control industry effects

4.3.1. Further Empirical Analysis

Table 11 shows the results for the relationship between derivative use and ROA as the measure of firm performance for the two sub-samples with ROA value higher and lower than the median value of the full sample, respectively. As shown in Column 1 in Table 11, the coefficient for the effect of derivative use carries a negative sign for the sub-sample with better performance (ROA > median), indicating a potentially negative effect on Tobin's Q as a measure of firm performance, but this effect is not significant. On the other hand, the negative effect of derivative use for sub-sample with poorer performance (ROA < median) is highly significant. These results clearly demonstrate that derivative use has a negative effect on performance, mainly for those firms that performed poorly.

Table 11. The effects of derivatives usage on Tobin's Q for groups separated by the median ROA value ¹.

	ROA > Median (0.0370)	ROA < Median (0.0370)
Derivative_dummy	−0.047 (−1.47)	−0.089 *** (−2.70)
Size	−0.364 *** (−42.89)	−0.511 *** (−64.77)
Dividend_dummy	−0.024 (−0.53)	0.036 (0.69)
Capital Expenditure	0.203 *** (2.99)	0.130 ** (2.05)
Cash Holding	0.100 *** (4.62)	0.173 *** (7.77)
Cash Flow	0.399 *** (7.04)	0.101 * (1.79)
CEO_TS	0.087 ** (2.51)	−0.025 (−0.61)
Fixed Effects	YES	YES
N	3756	3202
R2	0.649	0.755
Adjust R2	0.643	0.751

¹ In this table, the sample is grouped by the median value of ROA (0.0370). For the group in which ROA is greater than the median value, the use of derivatives has no significant impact on firm value. For the group in which ROA is less than the median value, a significantly negative relationship between derivatives usage and firm value has been found (at 99% confidence). *t*-statistics in parentheses * *p* < 0.1, ** *p* < 0.05, *** *p* < 0.01.

As previously described, we also created two sub-samples based on the difference between firms that have a ROE value higher and lower than the median value of the full sample. We examined the effect of derivative use on Tobin's Q as the measure of firm performance, and the results of regression analysis are shown in Table 12. For the sub-sample of firms with higher ROE value (Column 1), the effect of derivative use has a negative value, but this negative coefficient is statistically insignificant, suggesting that derivative use does not have a significant effect on Tobin's Q as firm performance. On the other hand, the effect of derivative use on Tobin's Q is negative and significant for the sub-sample with lower ROE value (Column 2). These results confirmed the findings from Table 11.

Table 12. The effects of derivatives usage on Tobin's Q for groups separated by the median ROE value¹.

	ROE > Median (0.0700)	ROE < Median (0.0700)
Derivative_dummy	−0.051 (−1.47)	−0.069 ** (−2.16)
Size	−0.395 *** (−45.70)	−0.529 *** (−65.48)
Dividend_dummy	−0.032 (−0.61)	0.015 (0.33)
Capital Expenditure	0.195 *** (2.59)	0.147 ** (2.52)
Cash Holding	0.194 *** (7.88)	0.172 *** (8.76)
Cash Flow	0.488 *** (7.92)	0.140 *** (2.70)
CEO_TS	0.130 *** (3.39)	−0.011 (−0.31)
Control Year and Industry	YES	YES
N	3521	3441
R2	0.676	0.741
Adjust R2	0.670	0.737

¹ In this table, the sample is grouped using the median value of ROE (0.0700). Similar to Table 10, for the group in which the ROE is greater than the median value, the use of derivatives has no significant impact on firm value. For the group in which ROE is less than the median value, a significantly negative relationship between derivative usage and firm value is found (at 95% confidence). *t*-statistics in parentheses ** $p < 0.05$, *** $p < 0.01$.

4.3.2. Robustness Tests

For the robustness test, observations have been grouped, for both ROA and ROE, into those which occupy the lowest 25% of the whole sample and the highest 25% of the whole sample. The model of Carter et al. (2006) has also been used in this test. The condensed data represents the extreme observations from the sample and leads to a stricter test. It is expected that the relationship between derivatives usage and Tobin's Q will be significant and negative in the groups that represent the firms with the lowest ROA and ROE. Furthermore, it is expected that this relationship will be insignificant in the groups that represent the firms with the highest ROA and ROE. The results of this robustness test are shown in Tables 13 and 14.

Table 13. The effects of derivative usage on Tobin's Q for groups with high and low ROA ¹.

	ROA > p75 (0.0670)	ROA < p25 (0.0140)
Derivative_dummy	0.116 (1.17)	−0.075 *** (−2.73)
Size	−0.374 *** (−16.33)	−0.485 *** (−72.06)
Dividend_dummy	−0.195 (−1.25)	0.016 (0.37)
Capital Expenditure	0.272 (1.21)	0.112 ** (2.07)
Cash Holding	0.096 (1.44)	0.159 *** (8.51)
Cash Flow	0.026 (0.14)	0.137 *** (2.87)
CEO_TS	0.328 *** (3.37)	0.012 (0.36)
Fixed Effects	YES	YES
N	539	4345
R2	0.669	0.746
Adjust R2	0.633	0.743

¹ This table presents the relationship between the use of derivatives and firm value by using a more extreme grouping method. The sample is separated into two groups; one includes the firms which have the greatest 25% ROA from the total sample (0.0670), and one includes firms with the lowest 25% ROA from the total sample (0.0140). In keeping with the previous findings, for the group with lower ROA, derivative usage has a significantly negative impact on firm value (at 99% confidence), whereas, for the group with higher ROA, there are no significant effects on firm value from using derivatives. *t*-statistics in parentheses ** $p < 0.05$ *** $p < 0.01$.

Table 14. The effects of derivatives usage on Tobin's Q for groups with high and low ROE ¹.

	ROE > p75 (0.113)	ROE < p25 (0.030)
Derivative_dummy	−0.028 (−0.44)	−0.062 ** (−2.34)
Size	−0.412 *** (−25.70)	−0.500 *** (−73.99)
Dividend_dummy	−0.016 (−0.15)	0.027 (0.69)
Capital Expenditure	0.291 * (1.68)	0.148 *** (2.95)
Cash Holding	0.241 *** (4.02)	0.187 *** (11.28)
Cash Flow	0.240 * (1.93)	0.221 *** (5.02)
CEO_TS	0.466 *** (5.35)	0.096 *** (3.28)
Fixed Effects	YES	YES
N	955	5033
R2	0.737	0.726
Adjust R2	0.721	0.723

¹ This table presents the relationship between the use of derivatives and firm value by using a more extreme grouping method. The sample is separated into two groups: one includes the firms which have the greatest 25% ROE from the total sample (0.113), and one includes firms with the lowest 25% ROE from the total sample (0.030). In keeping with the previous findings, for the group with lower ROE, derivative usage has a significantly negative impact on firm value (at 95% confidence), whereas, for the group with higher ROA, there are no significant effects from using derivatives on firm value. *t*-statistics in parentheses * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$.

Table 13 shows that, for the firms in the group with the lowest 25% ROA, using derivatives has a −0.075 effect on their value (Tobin's Q), which is significant at the 99%

confidence interval. Conversely, when it comes to the firms in the group that have the highest 25% ROA, derivative usage does not have any impact on a firm's value.

The same grouping method was used for ROE (as shown in Table 14). Although the coefficient of derivative usage, in the group which includes firms with the lowest 25% ROE (-0.062), is slightly lower than the group in which observations are lower than the median value of ROE of the sample (-0.069), the significant and negative relationship substantiates the previous findings.

In summary, through conducting additional regression analyses by splitting full samples into sub-samples along the two dimensions of ROA and ROE, respectively, our further analyses and robust tests confirmed the results generated from our initial analysis regarding the relationship between derivative use and firm performance.

5. Conclusions

This study aims to examine derivative use as the hedging against financial risks at the firm level in the research setting of emerging economies. While investment to financial derivatives is quite common for firms from developed economies, it is still a newly emerged economic and business phenomenon. Thus, there is a need to study firms' derivative use in the context of firms from emerging economies. This study addresses two research questions regarding investment in financial derivatives by firms from emerging economies: (1) what factors at the firm level leads firms to invest in financial derivatives? (2) Can derivative use lead to improvement of a firm's performance? These two research questions are examined in the context of Chinese firms that were listed on the Shenzhen Stock Exchange. Empirical data were collected from the CSMAR. In addition, data regarding firms' derivative use were collected manually for all the individual firms included in the sample. In total, the full sample includes 15,309 firm-year observations, covering a period of 11 years from 2005 to 2015.

To address the first research question, we followed prior studies in the developed economy setting to examine whether the firm characteristics in terms of firm size, operational cash flow, R&D investment, tax shield, the possibility of bankruptcy, and firm ownership would result in firms' investment in financial derivatives. To address the second research question, we adopted the conceptual model developed by Lau (2016) for regression analysis. Further, we performed additional analyses and robust tests to examine the relationship between derivative use and firm performance by splitting the full sample into sub-sample along the two dimensions of ROA and ROE.

This study contributes to the literature of derivative use by providing the following empirical findings based on a research setting of firms from China as a leading emerging economy. First, our study has identified firm characteristics of firm size, operational cash flow, R&D investment, tax shield, and the possibility of bankruptcy as the factors that determine firms' decision to invest in financial derivatives. Second, firms' ownership structures in terms of state-owned or private ownership do not affect a firm's decision on derivative use. Third, as a general tendency, derivative use has a negative effect on the firm's performance, and state-owned or private ownership does not change this negative effect. Fourth, firms with poorer performance are more likely to invest in financial derivatives, but derivative use tends to further reduce, rather than improve the performance of these firms.

These empirical findings have theoretical as well as practical implications regarding derivative use by firms from emerging economies such as China. First, prior research identified an association between certain firm-specific characteristics and firm investment in financial derivatives in the context of firms from developed economies (Allayannis and Ofek 2001; Haushalter 2001; Kuersten and Linde 2011; Titman and Grinblatt 2002). The empirical evidence based on our empirical findings confirmed such association in the setting of firms from China as an emerging economy. Secondly, but more importantly, our empirical findings shed new light on the relationship between derivative use and firm performance. Prior research in the context of firms from developed economies suggests

that derivative use tends to lead to improvement of firm performance (Allayannis and Weston 2001; Carter et al. 2006). The findings from our study provide empirical evidence of a negative effect of derivative use on firm performance. Moreover, while firms with poorer performance are more likely to invest in financial derivatives with the purpose of facilitating the improvement of performance, derivative use by these firms would further reduce their performance. We think that two factors may contribute to such a vicious cycle. The first is the serious flaws in the development of the derivatives market in developing or emerging economies, given its status of late development and poor institutional quality. The second is firms' lack of experienced professionals to operate the transactions for investment in financial derivatives. Third, the empirical findings regarding the relationship between derivative use and firm have practical implications both for the policymakers and managerial executives in the emerging economy setting. For the policymakers in developing and emerging economies, it is important to provide a business environment with high institutional quality for the development of derivative market performance. For the managerial executives of firms in developing and emerging economies, it is imperative to develop the skills and expertise required to effectively operate investments in financial derivatives.

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