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R&D Investment and Stock Returns: Evidence from China

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Abstract

Using a sample of Chinese listed firms with non-missing R&D expenditures from 2007 to 2018, this study investigates the relation between R&D investment and future stock returns in the Chinese stock market by portfolio-level analyses and firm-level Fama-MacBeth cross-sectional regressions. The results show that the relation between R&D investment and future stock returns is positive and statistically significant in the Chinese stock market. The positive R&D-return relation is robust to control for firm size, book-to-market ratio, asset growth, profitability, and state-owned enterprise ownership, as well as industry fixed effect. Consistent with the evidence in U.S. and European market, this finding supplements the study of R&D valuation by providing the empirical evidence in a major emerging and transition economy. Additionally, the results from univariate regressions show that among R&D-active firms, the value effect is insignificant, while the investment and state-owned ownership effect are more pronounced.

Keywords : R&D investment, R&D intensity, R&D-active firm, Chinese stock market.

1. Introduction

Research and development (R&D) is the major driver of technology innovation-hence the central role of R&D in economic growth and welfare improvement (Lev, 1999). Unlike capital investment, the innovation project involves a long process that is full of uncertainty and has a high failure rate (Holmstrom, 1989), so it is more complex to evaluate the value of R&D investment for market participants. An appropriate valuation of the R&D effect on stock returns could help investors to evaluate their investment strategies, and provide managers with useful insights into the long-term benefits of R&D for stock returns (Duqi et al., 2015).

A large body of literatures have confirmed the positive R&D effect on future stock returns using U.S. data. For example, Lev, Sougiannis (1996) and Chan et al. (2001) report a significantly positive relation between R&D investment level and future stock returns. Penman, Zhang (2002) and Lev et al. (2005) show that the changes in R&D are significantly related to subsequent stock returns. Besides, Eberhart et al. (2004) provide evidence that firms experience long-term higher abnormal stock returns and operating performance following substantial R&D

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increases. Recently, Hirshleifer et al. (2013) report that innovation efficiency (measured as R&D output to R&D input) is a robust positive predictor of future stock returns. Although such a positive R&D-return relation has reached a consensus based on U.S. data, the empirical evidences from international markets are mixed. For instance, Nguyen et al. (2010) find no evidence that the R&D expenditures are undervalued in the Japanese market. Duqi et al. (2015) find that R&D-intensive firms can earn superior stock returns compared to matched size and book-to-market portfolios across five European financial markets. In the Korean market, Lee (2017a) finds that R&D will increase firm value in large firms, while decrease firm value in diversified firms. Kim (2017) shows that there is a strong U-shape relationship between R&D expenditure and firm's growth potential.

The existing studies about the R&D effect on stock returns mainly focus on U.S. and other developed markets, while the relevant studies based on the emerging markets are very few. As the world's largest emerging market, China is an ideal setting to further test the valuation of R&D investment. Firstly, China's political and economic environment are quite different from U.S. and other developed economies, and China's market and investors are separated from the rest of the world (Liu et al., 2019). Besides, as an emerging and transition economy, the protection of intelligence property rights is much weaker than developed economies (La Porta et al., 2004). Thus, the evidence from developed markets cannot simply apply to the Chinese market. Secondly, during the past decades, China has witnessed a R&D explosion (Boeing et al., 2016). Before 2001, China's R&D expenditures were below 1% of its GDP but have risen to 2.11% upon 2016, compared with around 2.74% in the United States, 2.93% in Germany and 3.14% in Japan (see 2018 China statistical yearbook on science and technology, Table 10-1). Among the heavy investments, business enterprise sector contributes above 70% to the total R&D expenditures (see 2018 China statistical yearbook on science and technology, Table 10-2), which provides us a big sample to study the R&D effect in the stock market. Thirdly, the China's reform of R&D accounting treatment in 2007 provides us an accounting context different from U.S.. According to the China's firm accounting principle issued in 2001 (No. 13, intangible assets), all R&D expenditures are required to be immediately expensing and recorded as current profit or loss. In order to converge the China accounting standards (CAS) with international financial reporting standards (IFRS) and motivate firms' technological innovation, China issued a new version in 2006 and took effect in 2007. One of the most important changes is the accounting treatment of R&D expenditures (No. 6, intangible assets). Accordingly, the R&D expenditures should be divided into expenditures incurred in research stage and development stage. The expenditures incurred in research stage are required to be immediately expensing and recorded as current profit or loss, while the expenditures incurred in development stage are conditionally capitalizing and recorded as development expenditures in balance sheet. Since many studies argue that mispricing of R&D is caused by the immediately expensing of R&D expenditures according to U.S. GAAP (Penman, Zhang, 2002; Lev et al., 2005), this study can provide incremental evidence for this explanation based on Chinese accounting context.

In the context of Chinese market, due to the constraints of data availability in the early stage, the empirical studies on the stock market valuation of R&D are very few, and the limitations in the sample and R&D metrics also weaken the validity of their findings. For example, Luo et al. (2009) find that the high R&D firms have higher future operating profits and higher stock return in the next year. However, their sample only contains 177 listed firms in a short period from 2002 to 2006, which are manually collected from annual financial statements. Chen et al. (2010) also report a significantly positive relation between R&D and subsequent returns during the sample period from 1995 to 2007. However, their proxy for R&D expenditures is management expense, a noisy metric. Besides the problems caused by small sample and noisy metric, these studies merely focus on the pre-2007 period, and cannot incorporate the effect of the R&D accounting treatment reform. Thus, further examination of the R&D effect is required, especially for the post-2007 period.

Motivated by previous literatures, this paper aims to contribute new evidence to the literature by investigating the R&D effect on future stock returns using a big sample of Chinese A-share firms from 2007 to 2018. The R&D spending data is collected from China's listed firm's R&D innovation database, which is a sub-database in CSMAR database, covering the R&D-related data, patents data, and financial statements for firms reporting R&D information. Following Kumar, Li (2016), the firms with non-missing R&D expenditures are defined as R&D-active firms. In this study, the R&D intensity is measured as the firm's annual R&D expenditures scaled by its book assets (RDA) following recent studies (Li, 2011; He, Tian, 2013).

The results can be summarized as follows. Using a sample of 2058 R&D-active firms from 2007 to 2018, this study employs portfolio-level analyses and firm-level cross-sectional regressions and find a significantly positive relation between R&D investment and future stock returns in the Chinese stock market. Specifically, the R&D-active firms are sorted into quintile portfolios based on their R&D intensity at the end of June in year t, and then the monthly returns on these portfolios from July in year t to June in year t+1 will be calculated. For both value- and equal-weighted portfolios, the average raw returns and risk-adjusted returns on the high-minus-low RDA portfolios are significantly positive. This finding supplements Chan et al. (2001) and Duqi et al. (2015) by providing the empirical evidence of positive R&D return premium in a major emerging equity market. Then the examination of firm characteristics on R&D quintile portfolios shows that firms with higher RDA generally have smaller size, lower book-to-market ratio, lower asset growth, lower state-owned ownership, and higher profitability. Furthermore, after controlling for these characteristics by double-sorting method, the positive R&D-return relation remains statistically significant. Finally, firm-level cross-sectional regressions are conducted as further robustness tests. After controlling for firm size, book-to-market ratio, asset growth, profitability, state-owned ownership, and industry dummies simultaneously, the R&D intensity can still predict the future stock returns. Besides, some interesting patterns are also found among R&D-active firms. For example, the value effect disappears, whilst the asset growth and state-owned ownership are statistically significant in univariate regression models. These patterns are different from that documented in previous literatures using sample of all Chinese A-share firms, such as significant value effect (Carpenter et al., 2015; Liu et al., 2019), insignificant investment effect (Guo et al., 2017; Hsu et al., 2018) and insignificant state-owned ownership effect (Carpenter et al., 2015).

The remainder of the paper is organized as follows. Section 2 describes our sample and variables, as well as the empirical methodologies. Section 3 presents the empirical results. Section 4 concludes.

2. Data and methodology

2.1. Data

The stock return data and financial statement data are obtained from CSMAR database. In particular, the R&D expenditure data is collected from China's listed firm's R&D innovation database, which is a sub-database in CSMAR. The risk-free rate and Fame-French-Carhart four factors are obtained from RESSET database.

The sample contains the A-share firms with non-missing R&D expenditures listed on the main board in Shanghai and Shenzhen Stock Exchange. Since the R&D reporting principle in China was standardized in 2007 based on the new firm accounting principle (No.6, intangible assets), the sample period spans from 2007 to 2018. To make sure that all accounting variables are available, the accounting data of fiscal year t-1 is matched with returns from July of year t to June of year t+1. Following Fama, French (1993), the financial firms and firms with negative book value of equity are excluded.

Table 1 presents the industry distribution of R&D expenditures for R&D-active firms. The industry classification code is defined by China Securities Regulatory Commission (CSRC) industry classification 2012 version (first digit). Table 1 shows that among the 2058 R&D-active firms, over 70% are in manufacturing industry, and that more than 5% are in information and software industry. Following Chan et al. (2001), the R&D intensity is measured as the ratio of R&D expenditures relative to either book assets, sales, earnings (net income), market value of equity, or book value of equity. Instead of calculating the average ratios across firms, each of these ratios are calculated by aggregating separately the items in the numerator and denominator within each industry and then averaged across years. This procedure is not sensitive to outlier cases where a firm has extremely low or no earnings. R&D spending is heavily concentrated in technology and science-oriented industries. The highest ratio of R&D-to-sales is found in software and information technology (I), where R&D is about 5% of sales and 54% of earnings on average. Next in the industry ranking is scientific research and technology services (M), where the R&D cost is 3.4% of sales and 61% of earnings. Furthermore, the R&D spending in manufacturing industry is about 2.6% of sales and more than 42% of earnings. In short, the R&D intensity in Chinese public firms is much lower than that in U.S. public firms, whereas Chan et al. (2001) report that the R&D cost in the computer programming, software, and services industry represent about 17% of sales and two times of earnings.

Table 1. Industry distribution of R&D intensity

			R&D expenditures relative to				
Industry	Industry description	N	Assets	Sales	Earnings	ME	BE
A	Agriculture, forestry, animal husbandry and fishery	28	0.009	0.020	0.178	0.003	0.015
B	Mining	56	0.006	0.009	0.104	0.007	0.011
C	Manufacturing	1487	0.020	0.026	0.425	0.017	0.044
D	Electricity, heat, gas and water production and supply	54	0.002	0.005	0.069	0.002	0.004
E	Construction	72	0.009	0.012	0.387	0.029	0.041
F	Wholesale and retail trades	65	0.007	0.004	0.210	0.007	0.018
G	Transport, storage and post	39	0.002	0.004	0.089	0.003	0.005
H	Hotel and Restaurant	4	0.001	0.001	0.011	0.000	0.001
I	Information transmission, software and information technology services	111	0.028	0.051	0.541	0.013	0.048
K	Real estate	34	0.001	0.004	0.040	0.002	0.004
L	Leasing and business services	21	0.002	0.002	0.033	0.001	0.004
M	Scientific research and technology services	19	0.030	0.034	0.611	0.016	0.063
N	Management of water conservancy, environment and public utilities	17	0.003	0.011	0.073	0.002	0.007
P	Education	2	0.010	0.017	0.425	0.003	0.021
Q	Health and social work	5	0.008	0.011	0.181	0.004	0.012
R	Culture, sports and entertainment	29	0.015	0.026	0.467	0.011	0.030
S	Conglomerates	15	0.006	0.018	0.198	0.004	0.012
	All R&D firms	2058	0.009	0.015	0.238	0.007	0.020

Notes: This table reports summary statistics of R&D intensity classified by industry for R&D-active firms from 2007 to 2017. The industry classification is based on the CSRC industry classification 2012 version (first digit). The "N" indicates the number of firms within each industry. R&D intensity is measured as the R&D expenditures relative to either book assets, sales, earnings, market equity (ME), or book equity (BE). Each year, for each measure, the items in the numerator and denominator are aggregated separately within each industry. Then the average ratios across years for each industry is calculated, respectively.

2.2. Variable construction

The R&D intensity is measured as the ratio of R&D expenditures to total assets (RDA) at the end of prior calendar year (Li, 2011; He, Tian, 2013). Alternatively, the R&D intensity can also be measured as the R&D expenditures relative to either sales (RDS), market value of equity (RDE), or book value of equity (RDBE). Asset growth (AG) is measured as the changes in total assets from year t-2 to t-1 divided by total assets at the end of year t-2 (Cooper et al., 2008).

Profitability (ROE) is measured as the net income scaled by book value of equity at the end of year t-1. State-owned enterprise (SOE) is measured as the percentage of shares held by the central or local government in the previous month (Carpenter et al., 2015). Furthermore, the industry dummies (ID) are based on the CSRC industry classification 2012 version (first digit).

Table 2. Summary statistics

Panel A: Descriptive statistics

	Mean	Std. Dev.	Q1	Median	Q3
RET	0.0164	0.0974	-0.0355	0.0201	0.0701
RDA	0.0199	0.0021	0.0187	0.0193	0.0217
RDS	0.0340	0.0331	0.0122	0.0286	0.0435
RDME	0.0128	0.0138	0.0040	0.0084	0.0162
RDBE	0.0374	0.0357	0.0136	0.0278	0.0490
SIZE	22.40	0.48	22.01	22.21	22.98
BM	0.3735	0.1162	0.2467	0.3698	0.5077
AG	0.4249	0.2423	0.2612	0.4001	0.4467
ROE	0.0703	0.0202	0.0537	0.0671	0.0861
SOE	0.0618	0.0643	0.0246	0.0320	0.0708

Panel B: Pearson's correlation coefficients

	RET	RDA	RDS	RDME	RDBE	SIZE	BM	AG	ROE	SOE
RET	1									
RDA	0.019 **	1								
RDS	0.020 *	0.762 ***	1							
RDME	0.016 **	0.577 ***	0.314 ***	1						
RDBE	0.014 **	0.838 ***	0.569 ***	0.735 ***	1					
SIZE	-0.051 ***	-0.003	-0.037 ***	0.056 ***	0.034 ***	1				
BM	0.011	-0.218 ***	-0.242 ***	0.363 ***	-0.153 ***	0.058 ***	1			
AG	-0.013 **	-0.041 ***	-0.017 ***	-0.014 ***	-0.012 ***	0.143 ***	-0.008 ***	1		
ROE	-0.009	0.142 ***	0.024 **	-0.040 ***	0.021 ***	0.364 ***	-0.143 ***	0.111 ***	1	
SOE	-0.018 ***	-0.071 ***	-0.070 ***	0.029 ***	-0.012 **	0.209 ***	0.074 ***	0.119 ***	0.000	1

Notes: This table reports the time-series averages of cross-sectional descriptive statistics and Pearson correlations for R&D-active firms. The sample period is from 2007 to 2018. RET is the monthly raw return. RDA is measured as R&D expenditures divided by book assets at the end of fiscal year t-1. The RDA, RDS, RDME, and RDBE are measured as R&D expenditures scaled by book assets, sales, market equity, and book equity at the end of year t-1, respectively. Firm size (SIZE) is measured as the natural log of market capitalization (in Yuan) at the end of June in year t. Book-to-market (BM) is measured as book to market equity at the end of fiscal year t-1. Asset Growth (AG) is measured as the change in total assets from year t-2 to t-1 divided by total assets at the end of year t-2. Profitability (ROE) is measured as the net income divided by book equity at the end of fiscal year t-1. State-Owned Enterprise (SOE) is measured as the percentage of shares held by the central or local government in the previous month. The significance at the 1%, 5%, and 10% levels are indicated by ***, **, and *, respectively.

Table 2 tabulates the summary statistics and correlation matrix for above variables from 2007 to 2018. Panel A of Table 2 reports the time-series averages of the cross-sectional descriptive statistics of above variables. The average monthly return of R&D-active firms is

1.64%. The means of RDA, RDS, RDME, and RDBE are 1.99%, 3.40%, 1.28%, and 3.74%, respectively, which are much lower than the R&D intensity in U.S. firms reported in Leung et al. (2016) and Hou et al. (2016). Even though China's absolute value of R&D expenditures has been the second largest in the world (see global innovation index 2018, Figure G), there is still a big gap in the R&D intensity between China and U.S. public firms.

Panel B provides the time-series averages of the cross-sectional Pearson correlations. The correlations between the RET and various R&D intensity measures are all positive and statistically significant except for RDS. These four R&D intensity measures are highly correlated with each other. SIZE is significantly correlated with RDS, RDME, and RDBE at 5% level, but not with RDA. As the main measure of R&D intensity, RDA is negatively correlated with BM, AG, and SOE, and positively correlated with ROE. This indicates that firms with higher R&D to book assets tend to possess lower book-to-market ratio, lower asset growth, lower state-owned ownership, and higher profitability.

2.3. Methodology

Firstly, we perform the univariate portfolio-level analysis to investigate the relation between R&D investment and future stock returns in the Chinese stock market. At the end of June of each year t from 2008 to 2017, the R&D-active firms are sorted into quintile portfolios based on their RDA. Then the monthly value- and equal-weighted returns are computed for each quintile from July of year t to June of year t+1. Finally, the average raw returns and risk adjusted returns relative to Fama-French three-factor model and Fama-French-Carhart four-factor model are estimated for the quintile portfolios and high-minus-low (H-L) portfolios. The corresponding results are presented in section 3.1.

To get a clearer picture of the composition of the high RDA portfolios, we estimate the firm characteristics for the RDA quintiles, such as R&D expenditures, a variety of R&D intensity measures, firm size (SIZE), book-to-market ratio (BM), asset growth (AG), profitability (ROE), and state-owned ownership (SOE). The average values of firm characteristics for quintile portfolios are estimated as follows. Firstly, the accounting variables at the end of fiscal year t-1 and the market capitalization at the end of June of year t are matched with monthly returns from July of year t to June of year t+1. Then these transformed monthly-frequency variables will be matched with other monthly-frequency variables in previous month. Then, each month, the R&D-active firms are sorted into quintile portfolios based on RDA and the average values of firm characteristics of stocks in each portfolio over that month will be computed. Finally, the time-series average of the monthly average values of each portfolio will be calculated.

Next, we employ the double-sorting methodology to examine whether the positive R&D-return relation is robust to control for these characteristics. Following Bali et al. (2011), for example, SIZE is controlled by first sorting the R&D-active firms into quintile portfolios based on the market capitalization at the end of June of each year t. Then within each SIZE quintile, the stocks are sorted into quintiles based on RDA at the end of year t-1 so that quintile 1 (quintile 5) contains stocks with the lowest (highest) RDA. These 25 (5×5) portfolios will be held from July of year t to June of year t+1. For brevity, the returns for all 25 portfolios are not reported. Instead, the returns averaged across the five size quintiles are reported to produce quintile portfolios with dispersion in RDA, but with similar level of size, and thus, these RDA portfolios control for differences in size. Then the average monthly raw returns and risk-adjusted returns for the high-minus-low (H-L) RDA portfolios will be computed. This procedure is repeated to control for other variables, such as BM, AG, ROE, and SOE. The results are presented in section 3.2.

So far, the significance of the R&D investment as a cross-sectional predictor of future returns has been investigated at the portfolio level. The portfolio-level analysis is non-parametric and enables us to examine the relation between RDA and future returns without specifying a specific functional form. However, the portfolio-level analysis loses much information through aggregation, and it cannot control for multiple effects or factors simultaneously (Fama, French, 2008). Consequently, we perform the firm-level Fama-MacBeth regressions as further robustness tests.

Each month, the cross-sectional regressions are run for the following specification and its nested versions;

$$RET_{i,t+1} = \lambda_{0,t} + \lambda_{1,t}RDA_{i,t} + \lambda_{2,t}SIZE_{i,t} + \lambda_{3,t}BM_{i,t} + \lambda_{4,t}AG_{i,t} \\ + \lambda_{5,t}ROE_{i,t} + \lambda_{6,t}SOE_{i,t} + \lambda_{7}ID_{i} + \epsilon_{i,t+1}$$

where $RET_{i,t+1}$ is the realized return on stock i in month t+1, RDA, BM, AG, and ROE are measured at the end of year t-1, $SIZE$ is measured at the end of June of year t, and SOE is measured over the previous month. Furthermore, it is necessary to control for industry fixed effect (ID), because there is substantial cross-industry variation in R&D expenditures and intensity due to different nature of industries (Lev, Souginannis, 1996). Finally, the time-series average of the regression coefficients and associated Newey-West (1987) t-statistics will be calculated and the results are reported in section 3.3.

3. Empirical results

3.1. Univariate portfolio-level analysis

In this section, we investigate the relation between R&D investment and future stock returns in the Chinese stock market by univariate portfolio-level analysis. Table 3 presents the value- and equal-weighted average monthly raw returns and risk adjusted returns for each RDA quintile portfolio.

The results in Table 3 show that the average monthly returns for the H-L RDA portfolio are significantly positive both on equal- and value-weighted basis. Panel A shows that the value-weighted monthly raw return on the H-L RDA portfolio is 0.83% (t-statistics=1.991). Moreover, the monthly three-factor alpha and four-factor alpha on the H-L RDA portfolio are 0.82% (t-statistics=1.961) and 1.02% (t-statistics=2.623), respectively. The same pattern is displayed when considering the equal-weighted average returns in Panel B. The equal-weighted monthly raw return on the H-L portfolio is 0.65% (t-statistics=2.159), which is slightly lower, but more statistically significant than the value-weighted return. In addition, the equal-weighted monthly three-factor alpha and four-factor alpha on the H-L portfolio are 0.70% (t-statistics= 2.488) and 0.86% (t-statistics=2.893), respectively.

In a nutshell, the results from univariate portfolio-level analysis indicate that the investment strategy that is long the high RDA portfolio and short the low RDA portfolio can produce significantly positive abnormal returns after controlling for common risk factors. These findings support our hypothesis that the relation between R&D investment and future stock returns is significantly positive in the Chinese stock market. These results are consistent with the evidence in U.S. and European market (Chan et al., 2001; Duqi et al., 2015).

Table 3. Returns and alphas on portfolios sorted by RDA

Quintile	Low RDA	2	3	4	High RDA	H-L
Panel A: Value-weighted portfolios						
Average ret	0.0074	0.0096	0.0092	0.0084	0.0157*	0.0083**
	(0.790)	(1.048)	(1.103)	(0.981)	(1.716)	(1.991)
FF-3 alpha	0.0001	0.0006	-0.0012	-0.0000	0.0082***	0.0082*
	(0.017)	(0.179)	(-0.412)	(-0.015)	(2.921)	(1.961)
FF-4 alpha	-0.0006	0.0014	-0.0007	0.0010	0.0096***	0.0102***
	(-0.172)	(0.448)	(-0.232)	(0.373)	(3.785)	(2.623)
Panel B: Equal-weighted portfolios						
Average ret	0.0129	0.0158*	0.0165*	0.0165*	0.0194**	0.0065**
	(1.382)	(1.685)	(1.738)	(1.803)	(2.104)	(2.159)
FF-3 alpha	0.0000	0.0014	0.0012	0.0028	0.0070***	0.0070**
	(0.009)	(0.695)	(0.457)	(1.390)	(3.207)	(2.488)
FF-4 alpha	-0.0008	0.0014	0.0017	0.0032	0.0077***	0.0086***
	(-0.327)	(0.660)	(0.671)	(1.608)	(3.717)	(2.893)

Notes: This table reports the time-series average of monthly average raw returns and alphas on value- and equal-weighted basis. The “H-L” column presents the return differences and alpha differences between the high and low RDA portfolios. At the end of June of each year t from 2008 to 2017, the R&D-active firms are sorted into quintiles based on RDA in the fiscal year ending of year t-1. Then the value- and equal-weighted monthly raw returns for each portfolio are calculated from July of year t to June of year t+1. Newey-West (1987) t-statistics with four lags are reported in parentheses. The significance at the 1%, 5%, and 10% levels are indicated by ***, **, and *, respectively.

To get a clearer picture of the composition of the high RDA portfolios, Table 4 presents summary statistics of firm characteristics for the quintiles sorted by RDA, such as R&D expenditures, a variety of R&D intensity measures, firm size (SIZE), book-to-market ratio (BM), asset growth (AG), profitability (ROE), and state-owned ownership (SOE).

As shown in Table 4, firms with higher R&D generally have smaller size, lower book-to-market ratio, lower asset growth, lower state-owned ownership, and higher profitability. These patterns are in line with the correlations in Panel B of Table 2. As expected, the high RDA portfolios also possess higher absolute value of R&D expenditures. For instance, the average R&D expenditures of firms in high RDA portfolio is 297.16 million Yuan, which is almost 10 times of the value in low RDA portfolio. From the perspective of relative level, the firms in high RDA portfolio invest 4.72% of total asset on average, compared to 0.22% for firms in low RDA portfolio.

Table 4. Firm characteristics for quintile portfolios sorted by RDA

Quintile	Low RDA	2	3	4	High RDA
R&D expenditure	30.30	87.39	137.73	144.27	297.16
RDA	0.0022	0.0093	0.0164	0.0246	0.0472
RDS	0.0050	0.0206	0.0324	0.0425	0.0700
RDME	0.0023	0.0080	0.0120	0.0170	0.0247
RDBE	0.0057	0.0192	0.0312	0.0467	0.0846
SIZE	22.62	22.35	22.27	22.35	22.46
BM	0.4404	0.3990	0.3691	0.3563	0.3019
AG	0.6484	0.2404	0.3688	0.2130	0.3222
ROE	0.0500	0.0565	0.0694	0.0801	0.1006
SOE	0.0931	0.0528	0.0469	0.0644	0.0494

Notes: This table reports the time-series averages of the average values within each month of various characteristics of stocks in each RDA quintile portfolio. Firstly, the accounting variables at the end of fiscal year t-1 and the market capitalization at the end of June of year t are matched with monthly returns from July of year t to June of year t+1. Then these transformed monthly-frequency variables will be matched with monthly market variables. Then, each month, the stocks are sorted into quintile portfolios based on RDA and the average values of firm characteristics of stocks in each portfolio over that month are computed. Finally, the time-series average of monthly average values of firm characteristics of each portfolio will be calculated. R&D expenditure is measured in million Yuan. Other variables are defined in Table 2.

The low R&D firms possess the largest size and the high R&D firms have smaller size, but there is no decreasing pattern across the lowest to highest RDA portfolios. Li (2011) also reports that high R&D firms are generally smaller than low R&D firms in U.S. market. Holmstrom (1989) interprets this phenomenon from the view of organization theory and argues that both the bureaucratization and risk-averse tendency in large firms are hostile to innovation. Besides, BM decreases monotonically with RDA, indicating that the high R&D firms tend to be growth stocks. Lev, Sougiannis (1999) also find similar evidence in U.S. market. In addition, as RDA increases across quintiles, the AG decreases sharply from 64.84% to 32.22%. This finding suggests that low R&D firms make much more ordinary capital investments than high R&D firms. Furthermore, the final row in Table 4 shows that SOE is almost decreasing with RDA, indicating that high SOEs have less incentive to invest in R&D. Specifically, the average SOE in low R&D firms is 9.31%, which is nearly twice of that in high R&D firms. Given the higher uncertainty of R&D investment output (Hall, Lerner, 2009) and the lower efficiency of internal capital allocation within state-controlled companies in China (Ljungqvist et al., 2015; Carpenter et al., 2015), this pattern is not surprising.

3.2. Bivariate portfolio-level analysis

Given these differing characteristics shown in Table 4, there is some concern that neither the three-factor nor the four-factor model used in Table 3 are adequate to capture the true difference in risk and expected returns across the RDA quintiles. Therefore, in this section, we conduct the bivariate portfolio-level analysis to verify whether the positive relation between RDA and future stock returns still holds after controlling for SIZE, BM, AG, ROE, and SOE individually. The results are presented in Table 5.

Table 5. Returns on portfolios of stocks sorted by RDA after controlling for SIZE, BM, AG, ROE, SOE

Quintile	SIZE	BM	AG	ROE	SOE
Panel A: Value-weighted portfolios					
Low RDA	0.0124	0.0075	0.0083	0.0074	0.0080
2	0.0142	0.0098	0.0112	0.0115	0.0087
3	0.0129	0.0094	0.0117	0.0108	0.0082
4	0.0149	0.0112	0.0112	0.0126	0.0109
High RDA	0.0172	0.0159	0.0169	0.0158	0.0134
H-L	0.0048*	0.0084***	0.0086**	0.0084**	0.0054
	(1.881)	(2.721)	(2.203)	(2.482)	(1.479)
FF-3 alpha	0.0056**	0.0070**	0.0085**	0.0078**	0.0057
	(2.080)	(2.069)	(2.027)	(2.463)	(1.522)
FF-4 alpha	0.0071**	0.0090***	0.0106**	0.0097***	0.0079**
	(2.534)	(2.690)	(2.546)	(3.113)	(2.071)
Panel B: Equal-weighted portfolios					
Low RDA	0.0138	0.0129	0.0132	0.0123	0.0121
2	0.0161	0.0149	0.0146	0.0158	0.0127
3	0.0151	0.0173	0.0164	0.0156	0.0151
4	0.0165	0.0167	0.0161	0.0175	0.0150
High RDA	0.0195	0.0193	0.0193	0.0199	0.0176
H-L	0.0057**	0.0064***	0.0061**	0.0076***	0.0055*
	(2.097)	(2.701)	(2.054)	(2.721)	(1.762)
FF-3 alpha	0.0063**	0.0063**	0.0067**	0.0067***	0.0061**
	(2.363)	(2.580)	(2.263)	(2.671)	(2.152)
FF-4 alpha	0.0077***	0.0079***	0.0082***	0.0082***	0.0078**
	(2.693)	(3.107)	(2.667)	(3.187)	(2.571)

Notes: This table reports the time-series average of monthly raw returns and alphas on portfolios sorted by RDA after controlling for SIZE, BM, AG, ROE, and SOE on value- and equal-weighred basis. The "H-L" row shows the average raw returns and alphas on the high-minus-low RDA portfolio. At the end of June of each year t from 2008 to 2017, the R&D-active firms are firstly sorted into quintiles based on each control variable , and then within each control variable quintile, the stocks are sorted into quintiles based on RDA. The value- and equal-weighted returns for these 25 (5×5) portfolios from July of year t to June of year t+1 are calculated. Finally, the returns across the five control quintiles are averaged. The RDA and control variables are defined in Table 2. Newey-West (1987) t-statistics with four lags are reported in parentheses. The significance at the 1%, 5%, and 10% levels are indicated by ***, **, and *, respectively.

The results in Table 5 are similar with that in Table 2. After controlling for SIZE, BM, AG, ROE, and SOE, the average raw returns and alphas on the H-L RDA portfolios are almost positive and statistically significant both on value- and equal-weighted basis, except for SOE.

Panel A reports the results for value-weighted portfolios. It is noteworthy that after controlling for SOE, the average raw return and FF-3 alpha on the H-L RDA portfolio remain positive but become insignificant at convention level. For SIZE, even though the average raw return and alphas on the H-L RDA portfolio decrease remarkably compared to Table 3, they are still positive and statistically significant at 10% or 5% level. Nevertheless, after controlling for BM, AG, and ROE, respectively, the average raw returns and alphas on the H-L RDA portfolios have little difference from that in Table 3. Moreover, Panel B presents the results for equal-weighted portfolios and display similar patterns with Panel A. Even after controlling for SIZE and SOE, the equal-weighted average raw returns and alphas on the H-L RDA portfolio are slightly different from the results from univariate portfolio analysis.

These results indicate that the well-known cross-sectional predictors such as firm size, book-to-market ratio, asset growth, profitability, and state-owned ownership cannot individually explain the positive R&D-return relation in the Chinese stock market.

3.3. Firm-level cross-sectional regressions

So far, we have tested the significance of the R&D investment as a predictor of future returns at portfolio level. In this section, we will perform the firm-level Fama-MacBeth cross-sectional regressions as robustness tests.

Table 6 presents the time-series averages of cross-sectional regression coefficients for the ten model specifications and associated Newey-West (1987) t-statistics. To save space, we do not report the average coefficients on industry dummies (ID). Model 1 is the univariate regression model on RDA. Model 2 adds industry dummies to Model 1. Model 3 to Model 7 are univariate regression models on SIZE, BM, AG, ROE, and SOE, respectively, while Model 8 contains all the five control variables. Model 9 is regression models on RDA and five control variables, and Model 10 controls for industry dummies additionally.

The results in Table 6 support our hypothesis. The RDA variable retains significant predictive power no matter for univariate or multivariate regressions. Specifically speaking, in Model 1, the average slope on RDA is 0.1088 (t-statistics=2.074), showing a significantly positive relation between R&D intensity and future stock returns, consistent with the findings in portfolio-level analyses. More precisely, when the R&D expenditures-to-total assets increases by one basis point, the monthly expected return will increase by 0.1088 basis point. In Table 4, the spread in RDA between quintile 5 and quintile 1 is approximately 4.5%, which yields an estimate of the monthly risk premium of 49 basis points. This return premium is similar with that in Table 3 and Table 5. Subsequently, after we control for industry fixed effect in Model 2, the average slope on RDA comes down to 0.0803 (t-statistics=1.790), but is still significant at 10% level.

The Model 3 to Model 7 provide some interesting evidence. In Model 3, the average slope on SIZE is -0.0065 (t-statistics=-3.034), suggesting that among R&D-active firms, the size effect is also significant. As shown in Model 4, the average slope on BM is 0.0040 (t-statistics=0.582), indicating that the value effect disappears among R&D-active firms. Lev, Sougiannis (1999) lend support to this finding, who argue that BM is a proxy for R&D effect, and find that the R&D subsumes the role of BM in the cross-sectional regressions. The results in Model 5 and Mode 7 show that both AG and SOE are significant and more pronounced among R&D-active firms, whereas previous literatures document insignificant results in the Chinese stock market. In Model 6, the average slope on ROE is -0.0097 (t-statistics=-1.045), indicating that profitability cannot predict future stock returns, consistent with previous studies. Subsequently, when we contain all five control variables in Model 8, the results for SIZE and BM have little difference with that in univariate regressions, while the AG and SOE turn to insignificant.

Table 6. Firm-level Fama-MacBeth regression results

Model	RDA	SIZE	BM	AG	ROE	SOE	ID	Nobs	Adj. R^2
1	0.1088**							101,162	0.008
	(2.074)								
2	0.0803*						YES	101,162	0.026
	(1.790)								
3		-0.0065***						100,555	0.021
		(-3.034)							
4			0.0040					101,162	0.015
			(0.582)						
5				-0.0021***				96,705	0.001
				(-2.749)					
6					-0.0097			104,482	0.007
					(-1.045)				
7						-0.0162**		104,555	0.003
						(-2.506)			
8		-0.0064***	0.0039	-0.0013	0.0146	-0.0075		83,230	0.056
		(-3.325)	(0.594)	(-1.595)	(1.656)	(-1.590)			
9	0.0975**	-0.0063***	0.0044	-0.0012	0.0128	-0.0065		83,230	0.061
	(2.343)	(-3.321)	(0.688)	(-1.478)	(1.479)	(-1.400)			
10	0.0797**	-0.0058***	0.0038	-0.0011	0.0125	-0.0048	YES	83,230	0.073
	(2.191)	(-3.068)	(0.630)	(-1.270)	(1.429)	(-1.074)			

Notes: This table reports the time-series averages of cross-sectional regression coefficients. Each month from July 2008 to June 2018, the firm-level cross-sectional regressions of the excess return on lagged RDA, control variables, and industry dummies are run. The accounting data of fiscal year t −1 are matched with the returns from July of year t to June of year t+1. The RDA and other variables are defined in Table 2. The industry dummies are based on the CSRC industry classification 2012 version (first digit). All the independent variables are winsorized at bottom and top 1th percentile. Newey-West (1987) t-statistics with four lags are reported in parentheses. The significance at the 1%, 5%, and 10% levels are indicated by ***, **, and *, respectively.

Of the primary interest is the Model 9 and Model 10, which show the results for the full specification with RDA and five control variables, as well as industry dummies. In Model 9, the average slope on RDA is 0.0975 (t-statistics=2.343), slightly lower than that in the univariate regression. After controlling for industry dummies in Model 10, the average slope on RDA comes down to 0.0797, but remains statistically significant at 5% level. These results confirm that the positive R&D-return relation is robust to control for multiple effect simultaneously.

In short, the results from firm-level cross-sectional regressions provide further evidence for the positive R&D-return relation and confirm that the R&D effect cannot be explained by the well-known return predictors. These findings are consistent with Luo et al. (2009).

4. Conclusion

Using Chinese listed firms with non-missing R&D expenditures during the period from 2007 to 2018, this study investigates the relation between R&D investment and future stock returns in the Chinese stock market by portfolio-level analyses and firm-level Fama-MacBeth cross-sectional regressions. The results show that the relation between R&D investment and future stock returns is positive and statistically significant in the Chinese stock market. After controlling for firm size, book-to-market ratio, asset growth, profitability, and state-owned enterprise ownership, as well as industry fixed effect, the positive R&D-return relation is still robust and significant. These findings are consistent with the evidence in U.S. and European market. This study is an important complement to the studies on R&D valuation by providing new evidence in an emerging and transition economy.

In the context of Chinese market, the result is consistent with Luo et al. (2009), which also report a positive relation between R&D investment and future stock returns using the sample period from 2002 to 2006. Since China changed the R&D accounting treatment standard from "immediately expensing" to "conditionally capitalizing" in 2007, our results suggest that the positive R&D-return relationship seems not to be caused by the R&D accounting treatment in the Chinese market.

Interestingly, the results from univariate regressions show that among R&D-active firms, the value effect is insignificant, while the investment and state-owned ownership effect are more pronounced. These patterns are different from that documented in previous literatures using sample of all Chinese A-share firms, such as significant value effect (Carpenter et al., 2015; Liu et al., 2019), insignificant investment effect (Guo et al., 2017; Hsu et al., 2018) and insignificant state-owned ownership effect (Carpenter et al., 2015).

Furthermore, the existing studies, mostly based on U.S. data, suggest three possible explanations on the R&D effect: risk premium, behavioral biases, or market frictions (Hou et al., 2016).

Further research is required to investigate the causes of R&D effect in the Chinese stock market. Given China's separation and the differences in economic and financial systems, the evidence in Chinese market can shed new light on the explanations of R&D effect.

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