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Assessing the Effectiveness of Fraud Detection Models

Sonia Yin[1,a], Xintong Lai[2,b,*], Xinyi Qin[3,c], Qiyue Yuan[4,d], Xingyu Chen[5,e]

[1]Ningbo Xiaoshi High school, Ningbo, 315012, China
[2]Department of Business, Macau University of Science and Technology, Macau, 999078, China
[3]Department of Business Management, Beijing Normal University Hong Kong Baptist University United International College, Zhuhai, 519085, China
[4]Department of Finance, King's College, London, WC2R 2LS, United Kingdom
[5]Department of ACES, University of Illinois at Urbana Champaign, Urbana, 61801, United States
a. yinsoniasx05@gmail.com, b. 467391564@qq.com, c. 1457690221@qq.com, d. k21039045@kcl.ac.uk, e. xingyu4@illinois.edu
**corresponding author*

Abstract: Our research seeks to determine whether the detection of potential fraud in China-listed U.S. companies could be measured by the U.S. M-Score and F-Score models. Then, we group the data for 18 pairs of companies to make a t-test defined as the average difference between firms' M-scores or F-scores before and after the fraud. Moreover, more detailed information about these companies, financial fraud methods and motives, and ways to prevent financial fraud. Through our preliminary research, these two U.S. detection models can be used to detect financial fraud for Chinese-listed U.S. companies in statistical significance. With this premise, we also do an additional t-test to prove the standing adverse effects of committing fraud on firms.

Keywords: China-listed U.S. companies, financial fraud, M-score, F-score

1. Introduction

On April 2, 2020, the China-based company Luckin Coffee Inc. disclosed to the US. Securities and Exchange Commission (SEC) the financial fraud made [1]. After the disclosure of Luckin Coffee Inc, the stock price decreased dramatically from $26.60 to $4.90 [2]. According to Stephanie Avakian, the director of the SEC enforcement department, the existence of financial fraud exposes inaccurate information to investors, leading to market instability.

Luckin Coffee Inc. is not a single case of publishing misleading financial information. From 2009 to 2013, the increasing financial fraud cases caused more market insecurity, and the SEC set up more research teams on financial fraud [3]. Besides the SEC, many third parties investigate companies involved in discovering potential corporate fraud in the financial market, such as Wolfpack research and Muddy Waters [4]. Therefore, since a large amount of financial fraud has been investigated, investors and related departments need to pay more attention to the credible information in financial statements.

In general, our research seeks to find out whether we could measure the detection of potential fraud in China-based companies. Fraud detection index. As a result of increasing cases of financial fraud, this induces greater market instability and causes the fluctuation of stock price, decreasing the

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investors' confidence in future investment. Under the study of Forensic Accounting, the scholar predicts false accounting by following the statistics model. The Beneish M-Score model forecasts famous financial fraud cases before corporate disclosure, accounting for an overall 71% of cases in fraud accounting [5].

Meanwhile, the measurement of the accrual index plays a vital role in detecting misstating companies, while the calculation of F-score model involves examining large amounts of accrual data [6]. Consequently, both research designs signify false accounting measurements. The research chooses eighteen pairs of companies with similar industry and market shares. We would introduce these companies' corporate backgrounds and methods for committing fraud in each company pair. Specifically, our research selects the mean difference of M-Score and F-Score to differentiate fraud companies and companies with a normal financial index. Then, we expect to conduct the research conclusion using the t-test statistics.

2. Research Design

2.1. M-score

Beneish M-Score is a model to detect whether companies tend to commit financial fraud on their financial statements. Empirically, a higher M-Score has a higher possibility of manipulation. Furthermore, Beneish M-Score is a probabilistic model, which means it can just show the probability of committing the fraud, not with 100% accuracy to detect fraud [7]. Table 1 shows all the variables for calculating M-score.

The formula is as follows:

$$MScore = -4.840 + 0.920*DSRI + 0.528*GMI + 0.404*AQI + 0.892*SGI + 0.115*DEPI - 0.172*SAI - 0.327*LVGI + 4.679*TATA$$

Table 1: M-score variables.

	Definition	Formula	Numerator year/Denominator year
DSRI	Days Sales in Receivables Index	Receivable/Sales	t/t-1
GMI	Gross Margin Index	(Sales-COGS)/Sales	t-1/t
AQI	Asset Quality Index	1 – ((Current assets + PP&E, net)/Total assets)	t/t-1
SGI	Sales Growth Index	Sales	t/t-1
DEPI	Depreciation Index	Depreciation/(Depreciation+PPE,net)	t-1/t
SAI	Sales, General and Administrative Expenses Index	SG&A/Sales	t/t-1
LVGI	Leverage Index	(LT debt+Current liability)/Total assets	t/t-1
TATA	Total Accruals to Total Assets	(Net income attributes to the company - Non-operating profit - Cash from operating activities)/Total assets	t

*Note:If M-Score is larger than -2.2, it indicates potential manipulation, and the higher is worse.

The M-Score model works because its variables can capture three main manipulation methods. First, some companies grow increasingly fast, which can be indicated by the Sales Growth Index.

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Second, some companies experience some economic headwinds, indicated by the Asset Quality Index, Gross Margin Index, SGA Index, and Leverage Index. Third, some companies practice aggressive accounting, indicated by Days in receivables, Depreciation Index, and Accruals to total assets [6].

2.2. F-score

The F-score model helps to detect accounting fraud. Researchers from the UCB and WU integrated all the disparate warning signs of accounting fraud in the F-Score model, which allowed it to calculate the probability that a firm is falsifying its account statement [6].

The F (Fudging) Score evaluates a company on five dimensions: Accrual quality, financial performance, non-financial indicators, off-balance sheet activities and market incentives. Users just input data from the company's public financial statements, the algorithm will calculate the result automatically. In America, the average firm score is 1; a higher score implies a higher probability of accounting fraud or misstatements.

F-score has accurately identified more than 60 percent of companies investigated by the SEC for misrepresentations during the study period. For example, in 2000, Enron had a PE ratio of 2.2, more than twice the average rate at which companies manipulated earnings.

However, a high F score does not prove wrongdoing; it merely causes suspicion: Some companies get a high F score without any financial or accounting mistake. Therefore, the F-Score should only be used as a preliminary screening device to detect possible misstatements.

Table 2: F-score variables.

Variable	Definition	Formula
rsst_acc	Change in non-cash net operating assets	ΔNon-cash net operating assets/Average total assets
ch_rec	Change in receivables	ΔReceivables/Average total assets
ch_inv	Change in inventory	ΔInventory/Average total assets
soft_assets	Percentage soft assets	(Total assets – PP&E, net – Cash & equivalents)/Total assets
ch_cs	Change in cash sales	% change in (Sales – ΔReceivables)
ch_roa	Change in return on assets	Change in ratio of Net income/Average total assets
issue	Debt or equity issuance	Equals 1 if LTD debt or common and/or preferred equity issued

Table 2 shows all the variables for calculating the F-score. To get F-score, we first need to calculate the predicted value, and use it to calculate the probability of manipulation. Then, we can get an F-Score. The formulas are as follows:

Predicted value =

-7.893 + 0.790*rsst_acc+2.518*ch_rec+1.191*ch_inv+1.979*soft_assets + 0.171*ch_cs – 0.932*ch_roa + 1.029*issue

Probability of manipulation = e^Predicted value/(1 + e^Predicted value) where e=2.71828183

F score= Probability of manipulation/0.0037

F > 1 indicates “above normal risk” and F > 2.45 indicates “high risk”. (DECHOW et al.)

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3. Data & Sample Selection

3.1. Companies Overview

Overall, as shown in Table 3, we select 18 Chinese Companies listed in the U.S. stock market in the past 15 years, which were reported to conduct accounting fraud, and 18 Companies listed in the U.S. stock market that did not manipulate (Chinese companies in the majority). The detailed information is in the table below, including the sectors companies belong to and the names of companies.

Table 3: Companies information.

Sector	Fraud Company	Paired Company
1.	**Link Motion**	**Renren**
Technology	Link Motion is a Chinese technology company that develops, licenses and sells smart ride software and services [8].	Renren is a Chinese social networking site similar to Facebook [9].
2.	**Universal Travel Group**	**Trip.com Group**
Travel Service	The company focuses on leisure and group travel services for the domestic and international travel markets [10].	Trip.com is an online ticketing service that allows consumers to book hotels, flights and train tickets online [11].
3.	**China-Biotics**	**Sinovac Biotech**
Medical	China Biopharmaceutical Co.Ltd are leading innovative pharmaceutical group in China, covering the whole industry chain of R & D, production and system [12].	Sinovac focuses on developing, producing and selling vaccines and related products for human use to prevent and control diseases [13].
4.	**Fushicopperweld**	**ACH Aluminum**
Material	Fushicopperweld is a professional company engaged in developing and producing copper-clad steel and aluminum wire for power equipment [14].	ACH Aluminum is the only alumina producer in China [15].
5.	**Focus Media**	**Sina**
Communication	Focus Media is the world's first elevator media. The main business is developing and operating life-circle media [16].	Sina is one of China's leading web portals, providing Chinese-language content to the Chinese community in mainland China and around the world [17].
6.	**JinkoSolar**	**Daqo New Energy**
New Energy	Jinkosolar is now the world's largest solar panel maker, with shipments of 11.4 G W in 2018 [18].	Daqo New Energy is a monocrystalline silicon and polysilicon manufacturer for use in solar photovoltaic systems [19].

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Table 3: (continued).

7.	Akso Health Group	Tarena International
Financial	Akso Health Group is mainly engaged in building a convenient and transparent lending platform for borrowers with capital needs and lenders with financial management needs [20].	Tarena is a famous financial and financial training institution in China committed to training medium and high-end software talents for telecom and financial fields [21].
8.	**TAL Education**	**RISE Education**
Education	TAL is an education technology company dedicated to public and private education. The company has built a diversified education ecosystem from tools, platforms and content to meet the personalized learning needs of all ages, from 1 to 24 years old [22].	RISE offers a highly dynamic US K-12 curriculum while providing students with interactive multimedia inside and outside the classroom [23].
9.	**JOYY**	**HUYA**
Communication	JOYY and its subsidiaries operate social media platforms that provide engagement and experience through a variety of video and audio social platforms [24].	HUYA is the largest game live streaming platform in China, with the largest and most active game live streaming community, as well as the largest active broadcasters in 2017 and 2018 [25].
10.	**GDS**	**Splunk**
Data	GDS offers a new outsourced, large-scale, high-performance data center solution that meets data center service standards for high efficiency and stability across core economic hubs [26].	Splunk provides an open, extensible data platform that enables sharing of data across any environment [27].
11.	**Beigene**	**Zai Lab**
Healthcare	Beigene was founded to deliver high-quality innovative medicines around the world faster, more easily and affordably than ever before [28].	Zai Lab is an innovative and research-based commercial-stage biopharmaceutical company that develops and delivers breakthrough therapeutics to patients around the world [29].
12.	**Uxin**	**Cango**
Financial	Uxin is China's leading national online used car dealer that established a revolutionary used-car supply chain [30].	Cango Group begins with vehicle loan marketing, expands into automotive trading and automobile aftermarket, and creates a service platform covering the entire value chain of automobile circulation [31].

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Table 3: (continued).

13.	Hello Group	Sohu.com
Media	MOMO mainly carries out technology development, basic software services, literary and artistic creation and other businesses [32].	Sohu is the latest information for users, and search, mail and other network services [33].
14.	**Pinduoduo**	**JD.com**
E-commerce	Pinduoduo is a new e-commerce platform, similar to Amazon. The company is committed to integrating social and entertainment activities into the e-commerce business [34].	Jingdong Group is a B2C shopping website that provides supply chain-based technology and services [35].
15.	**58.com**	**Leju**
E-commerce	Wuba has dozens of direct sales outlets in China. The company is mainly targeted at local communities and classified information, and is the largest life information website in Chinese [36].	Leju created a real estate home furnishing Internet platform. The platform provides new houses, second-hand houses, furniture and other information and services with a O2O marketing service system [37].
16.	**Lexinfintech**	**Fanhua**
Financial	Lexin provides an online digital platform for e-commerce and lending services [38].	Fanhua Holdings Group is a well-known comprehensive third-party financial services group in China [39].
17.	**IQiyi**	**Bilibili**
Communication	Iqiyi is Baidu's video platform, which also produces and distributes content. Iqiyi is one of the top five video platforms in China by market share [40].	Bilibili has built a high-quality online video system for the cultural community and a video platform highly gathered by the young generation in China [41].
18.	**Canaan**	**21 Vianet**
Technology	Canaan Technologies is positioned to provide computing power for new digital infrastructure with a diversified business strategy of "blockchain +AI" [42].	The company is committed to providing industry-leading one-stop solutions for data center customization for super-large customers and building an infrastructure operation platform [43].

3.2. Data Groupings

In this paper, we select both companies conducting financial fraud as our experimental groups and their pair companies that did not conduct financial fraud as our control groups. We use pair companies because we want to eliminate the impact of industry, time and other exogenous factors on M-Score and F-Score, so our conclusion is more reasonable and persuasive when we analyze the scores.

Our standards of the pair companies selection are according to industry, annual revenues, and employee scale. Manipulation companies and pair companies should have a similar index mentioned above, which makes the comparison meaningful.

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Table 4: Focus Media Holdings and its paired company.

Company name	Industry	Annual revenue	Employee scale
Focus Media Holdings	Media, Entertainment and Arts	$1.9 billion	6,779
Sina Corporation		$1~5 billion	5K~10K

Taking Focus Media Holdings (conducting fraud) and Sina Corporation as an example, from Table 4, it is clear that both companies belong to the media, entertainment and arts industries. Both companies earn about 2 billion dollars annually and have about 7000 employees. Even though some other companies may not have such a similar index because of limited Chinese companies listed in the U.S., we try to find the paired companies with the index as approximate as possible.

Furthermore, we group our data before fraud and during the fraud. Every company has a corresponding M-Score and an F-Score every year. For example, from the sample table (Table 5), Focus Media Holding was reported to conduct accounting fraud in 2011. Therefore, 2011 is the one group of data. In addition, data from 2007 to 2010 is the data before fraud and we will calculate the average number of it. For Sina Corporation, we also use the data of 2011 as the comparison with manipulation year and calculate the average scores from 2007 to 2010.

Furthermore, we use the same year of data between the fraud company and the paired company. In this example, both companies used the data from 2007 to 2011. You can see the complete data and detailed calculation in the fourth part "Analysis and result". Because of the large amount of data, we can eliminate chance errors and get a more accurate result instead of only looking at a couple of groups.

Table 5: The M-scores and F-scores for Focus Media Holdings and its paired company.

Focus Media Holdings (fraud)	Year	M-Score	Fscore	Sina Corporation (paired)	Year	M-Score	F-Score
	2007	-1.913	2.460		2007	-2.609	0.917
	2008	-4.768	2.471		2008	-2.396	0.876
	2009	-3.356	0.501		2009	-1.726	0.747
	2010	-2.277	0.734		2010	-2.334	1.364
	2011*	-2.752	1.773		2011	-2.577	1.094

Note: * means a year of manipulation.

4. Analysis & Result

4.1. T-test Design

The T-test is an inferential statistic used to assess whether there is a significant difference in the means of two groups [44]. For our study, we suggest the companies into two groups: companies conducting fraud and companies not conducting fraud. If the data of two groups are from the same population, their mean and deviation should be the same.

For our study, the mean of t-test is defined as the average difference between firms' M-scores or F-scores before and after the fraud.

Because fraud companies often intentionally change some index to manage their earnings or cash flow, their scores may diverge from the control group's companies (companies in the control group can represent a whole industry's general trend). Because of the disparity, a T-test can determine whether the models effectively distinguish between fraud and non-fraud companies.

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Besides, choosing average difference as the mean is based on the consideration that the M-score or F-score models may not be suitable for Chinese corporations. Therefore, the score we calculated for the firms may not be able to compare with the cutoff score used in the original models.

Therefore, we conduct a test of

$$H_0: \mu_1 - \mu_2 = 0$$
$$H_a: \mu_1 - \mu_2 \neq 0$$

where μ_1 is the actual main difference between the M-Score or F-Score of the fraudulent company before and during the fraud and $\mu_2$is the true mean difference between the M-score or F-score of the non-fraudulent company before the fraud and during the fraud. We use the significance level $\alpha = 0.05$ and the test we conducted is a two-tailed test. According to figure one, if we get the result within the 2.5% region, the H_0 can be rejected. Therefore, the t test statistic we get should be larger than t critical value if we want to reject H_0.

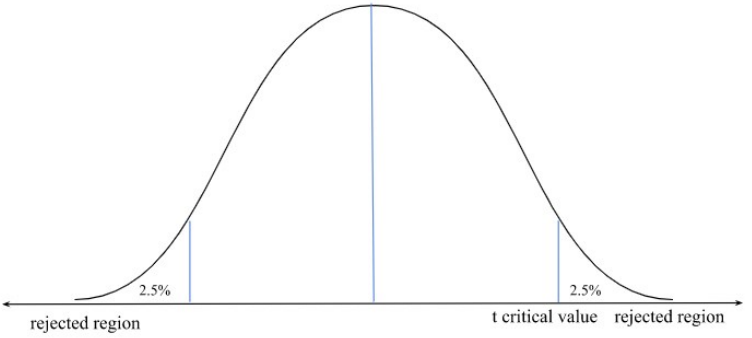

Figure 1: Two-tailed test.

4.2. Data Collection & Calculation for T-test

The table 6 displays the average score of fraud years and an average score of non-fraud years calculated. Then, the absolute value of $AVG_{fraud} - AVG_{non-fraud}$ is calculated and used as data for t-test.

Table 6: Summarized M-score, F-score, change of score data table.

Years	Experimental group						Control group					
	M-Score	AVG	$\|change\|$	F-Score	AVG	$\|change\|$	M-Score	AVG	$\|change\|$	F-Score	AVG	$\|change\|$
1	Link Motion NQ						Renren RENN					
2010	1.104	1.104	2.051	0.302	0.302	3.191	-2.839	-2.839	0.447	0.036	0.036	2.288
2011*	-0.808	-0.947		2.604	3.493		-1.647	-2.392		2.517	2.324	
2012*	-1.086			4.382			-3.113			2.131		
2	Universal Travel Group UTA						Trip.com Group TCOM					
2008	-0.296	-0.296	1.479	2.227	2.227	0.165	-2.540	-2.540	0.144	1.501	1.501	0.211
2009*	-2.408	-1.775		1.464	2.062		-2.452	-2.396		1.693	1.290	
2010*	-1.141			2.660			-2.339			0.886		
3	China-Biotics CHBT						Sinovac Biotech SVA					

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Table 6: (continued).

2008	-3.017	-2.975	1.110	0.354	0.420	0.057	-2.190	-2.488	0.680	0.838	0.685	0.162
2009	-2.932			0.486			-2.785			0.532		
2010*	-2.109	-1.865		0.478	0.477		-0.847	-1.808		0.681	0.523	
2011*	-1.621			0.475			-1.758			0.370		
4	Fushi Copper Weld FSIN						ACH Aluminum ALMMF					
2007	-0.963	-0.963	1.220	1.218	1.218	0.500	-1.590	-1.590	0.225	0.756	0.756	0.363
2008*	-1.197	-2.183		1.059	0.718		-2.105	-1.347		0.479	0.393	
2009*	-2.307			0.735			-0.093			0.521		
2010*	-2.259			0.580			-2.610			0.554		
2011*	-2.969			0.479			-0.579			0.016		
5	Focus Media FMCN						Sina SINA					
2007	-1.913	-3.079	0.327	2.460	1.541	0.302	-2.609	-2.260	0.317	0.917	0.976	0.118
2008	-4.768			2.471			-2.396			0.876		
2009	-3.356			0.501			-1.726			0.747		
2010	-2.277			0.733			-2.334			1.364		
2011*	-2.752	-2.752		1.773	1.773		-2.577	-2.577		1.094	1.094	
6	JinkoSolar JKS						Dargo New Energy DAQO					
2016	0.965	0.965	2.476	3.068	3.068	0.165	-2.829	-2.829	0.877	0.482	0.482	0.542
2017*	-1.511	-1.511		3.233	3.233		1.952	-1.952		0.602	0.602	
7	Akso Health Group AHG						Tarena International TEDU					
2017	-2.785	-2.785	2.866	0.483	0.483	0.986	-3.741	-3.741	0.822	0.643	0.643	0.026
2018*	3.973	0.081		0.569	1.469		-4.519	-4.293		0.650	0.669	
2019*	-3.812			2.368			-4.066			0.688		
8	TAL Education						Rise Education Group					
2017	-3.198	-3.198	4.558	1.323	1.323	0.240	-2.306	-2.306	1.139	0.463	0.463	0.006
2018*	0.640	0.640		1.563	1.563		-1.167	-1.167		0.469	0.469	
9	JOYY YY						HUYA HUYA					
2017	-2.828	-2.828	1.227	1.913	1.913	0.076	-1.011	-1.011	1.025	2.840	2.840	0.487
2018*	-2.279	-1.601		1.801	1.837		-0.761	-2.036		7.368	3.327	
2019*	-1.221			2.764			-2.857			1.474		

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Table 6: (continued).

2020*	-1.304			0.947			-2.491			1.138		
10	Global Data Solutions Limited GDS						Splunk SPLK					
2017	-1.730	-1.730	0.189	0.554	0.554	0.050	-3.741	-3.741	1.446	1.158	1.158	0.292
2018*	-1.883	-1.919		0.511	0.504		-2.787	-2.295		1.553	1.450	
2019*	-1.954			0.473			-2.721			0.726		
2020*	-1.919			0.487			-1.377			2.072		
11	Beigene BGNE						United Therapeutics Corporation UTHR					
2016	-4.143	-4.143	0.902	5.149	5.149	4.574	-2.119	-2.119	2.641	0.580	0.580	0.493
2017*	-3.607	-3.241		1.126	0.575		-1.916	0.522		1.255	1.073	
2018*	-2.875			0.024			-2.959			0.890		
12	Uxin UXIN						Cango CANG					
2017	-0.267	-0.267	2.472	1.613	1.613	0.201	-2.568	-2.568	0.629	2.461	2.461	0.298
2018*	-2.739	-2.739		1.814	1.814		-1.939	-1.939		2.163	2.163	
13	Hello Group MOMO						Sohu.com SOHU					
2015	-1.049	-1.049	0.050	2.007	2.007	0.864	-3.467	-3.467	0.796	1.166	1.166	0.058
2016*	-2.088	-1.099		3.488	2.871		-3.186	-2.671		0.933	1.224	
2017*	-0.110			2.253			-2.155			1.514		
14	Pinduoduo PDD						JD.com					
2017	-3.727	-1.673	0.036	1.425	3.141	2.563	-2.973	-2.993	0.410	1.497	1.329	0.442
2018	0.382			4.857			-3.013			1.160		
2019*	-1.164	-1.637		2.042	1.984		-3.091	-3.403		1.362	0.887	
2020*	-2.109			1.926			-3.714			0.412		
15	58.com WUBA						Leju LEJU					
2014	1.031	2.123	7.861	2.661	5.174	3.680	-2.739	-2.692	0.361	0.767	0.714	0.438
2015	4.616			3.936			-2.382			0.782		
2016	5.334			16.045			-3.038			0.512		
2017	-2.266			1.567			-2.878			0.867		
2018	1.893			1.659			-2.424			0.644		
2019*	-5.738	-5.738		1.494	1.494		-2.331	-2.331		1.152	1.152	
16	LexinFintech LX						Fanhua FANH					

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Table 6: (continued).

2017	-2.225	-3.037	1.293	0.067	0.461	1.525	-2.332	-2.924	0.061	1.371	1.143	0.785
2018	-3.848			0.854			-3.516			0.915		
2019*	-1.314	-1.744		1.942	1.986		-2.400	-2.863		2.168	1.928	
2020*	-2.174			2.029			-3.325			1.238		
17	IQiyi IQ						Bilibili BIU					
2018	-3.541	-3.541	0.149	5.052	5.052	3.847	-2.544	-2.544	0.131	1.529	1.529	0.054
2019*	-3.452	-3.392		1.398	1.205		-2.106	-2.413		1.383	1.475	
2020*	-3.331			1.012			-2.719			1.566		
18	Canaan CAN						21 Vianet VNET					
2018	5.908	-0.277	1.055	1.173	1.628	1.376	-2.941	-2.796	0.241	0.582	0.676	0.114
2019	-6.462			2.082			-2.650			0.769		
2020*	-1.332	-1.332		0.252	0.252		-3.037	-3.037		0.790	0.790	

4.3. T-test Result & Analysis

4.3.1. M-score Result

Calculated the data from the table above, we can get $\overline{x_1}$ =1.74006, $\overline{x_2}$ =0.68844, $s_1^2 = 3.700759, and\ s_2^2 = 0.386356$ for the two groups of data for M-score.

$$s^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2} = \frac{17 \times 3.700759 + 17 \times 0.386356}{34} = 2.04356$$

$$test\ statistic = \frac{(\overline{x_1} - \overline{x_2}) - (\mu_1 - \mu_2)}{\sqrt{s^2(\frac{1}{n_1} + \frac{1}{n_2})}} = \frac{(1.74006 - 0.68844) - 0}{\sqrt{2.04356 \times (\frac{1}{18} + \frac{1}{18})}} = 2.2069$$

$$degrees\ of\ freedom = \frac{\left(\frac{var_1^2}{n_1} + \frac{var_2^2}{n_2}\right)^2}{\frac{\left(\frac{var_1^2}{n_1}\right)^2}{n_1-1} + \frac{\left(\frac{var_2^2}{n_2}\right)^2}{n_2-1}} = \frac{\left(\frac{3.70076}{18} + \frac{0.38636}{18}\right)^2}{\frac{\left(\frac{3.70076}{18}\right)^2}{17} + \frac{\left(\frac{0.38636}{18}\right)^2}{17}} = 21$$

From t-table, when df=21, $\alpha = 0.05$, the critical value = 2.080 (data source: http://www.ttable.org/). As test statistic 2.2069 is larger than the critical value, H_0 can be rejected.

4.3.2. F-score Result

Calculated the data from table above, we can get $\overline{x_1}$ =1.35344, $\overline{x_2}$ ==0.39872, $s_1^2 = 2.322647, and\ s_2^2 = 0.268308$ for the two groups of data for M-score.

$$s^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2} = \frac{17 \times 2.322647 + 17 \times 0.268308}{34} = 1.295478$$

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$$test\ statistic = \frac{(\overline{x_1} - \overline{x_2}) - (\mu_1 - \mu_2)}{\sqrt{s^2(\frac{1}{n_1} + \frac{1}{n_2})}} = \frac{(1.35344 - 0.39872) - 0}{\sqrt{1.295478 \times (\frac{1}{18} + \frac{1}{18})}} = 2.5164$$

$$degrees\ of\ freedom = \frac{\left(\frac{var_1^2}{n_1} + \frac{var_2^2}{n_2}\right)^2}{\frac{\left(\frac{var_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{var_2^2}{n_2}\right)^2}{n_2 - 1}} = \frac{\left(\frac{2.322647}{18} + \frac{0.268308}{18}\right)^2}{\frac{\left(\frac{2.322647}{18}\right)^2}{17} + \frac{\left(\frac{0.268308}{18}\right)^2}{17}} = 21$$

From t-table, when df=21, $\alpha = 0.05$, the critical value = 2.080 (data source: http://www.ttable.org/). As test statistic 2.5164 is larger than the critical value, H_0 can be rejected.

4.3.3. Result Analysis

After conducting the t-test for M-Score and F-Score, we demonstrate that the M-Score and F-Score models effectively distinguish fraudulent and non-fraudulent companies as the H_a should be the correct hypothesis.

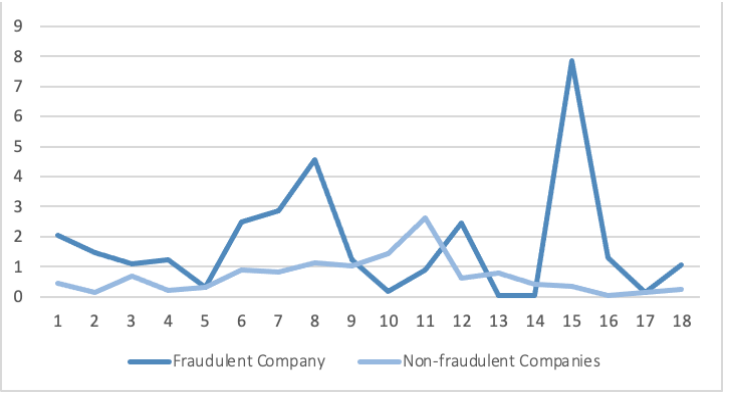

Figure 2: Change of M-score.

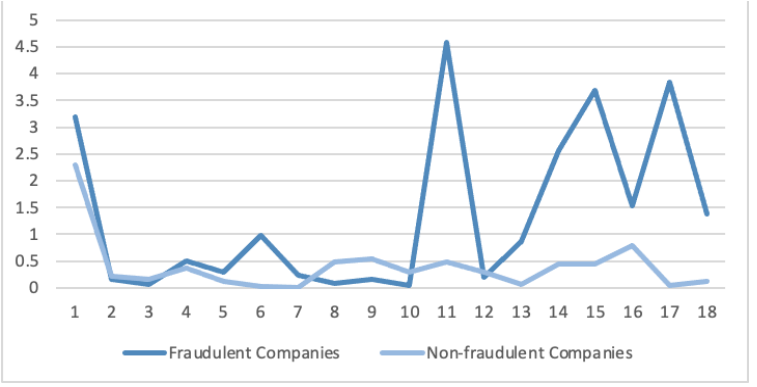

Figure 3: Change of F-score.

Figures 2 and 3 generated from the data table using excel show the changes of M-score and F-score for non-fraudulent companies are more violent. These trends imply that financial report manipulations may cause the company's index to be unstable, making future forecasting difficult.

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4.4. Limitations

4.4.1. T-test's Limitation

First, some non-fraudulent companies that represent their whole industries may have a change in M-score or F-score larger than fraudulent. Therefore, the trend of changing M-score or F-score is not constant. The mean change of M-score or F-score for fraudulent firms will drop due to the reversion of the trend. The mean difference and variance are two important parameters influencing the t-test result. As a result, the opposite trend will cause the disparity of means between fraudulent and non-fraudulent companies to reduce in size, reducing the likelihood of rejecting the H_0.

Many fraudulent companies, they start counterfeiting when they first go public. Even though we use the data from the registration statement, the years of data available are limited. With only two or three years of M-Score or F-Score, the change value will be highly influenced by one specific value. For this study, we use larger samples to eliminate the individual effect on the whole t-test result.

4.4.2. Models' Limitations

When we apply models to individual companies, the result shows that the cutoff value of -1.89 (M-Score model) and 2.48 (F-Score model) for U.S. companies may no longer be suitable for U.S. listed Chinese companies. For example, HUYA or Cango is non-fraudulent companies, but the model may categorize them as having a high risk of committing fraud. Therefore, when we analyze, we focus on the whole picture of whether the models are used instead of applying to single firms.

5. Testing the Prolonged Effect of Committing Fraud

5.1. Design of the Test

We demonstrate that the models effectively determine whether companies engage in fraud after doing the t-test. With this premise in mind, we decide to conduct another t-test to see if committing fraud long-term affects the companies. We calculate the average M-score or F-score before and after the fraud and get the mean difference. The t-test is then used to evaluate whether there is a difference between companies that committed fraud and those that did not. So, H_0 assumes $\mu_1 - \mu_2 = 0$ and H_a assumes $\mu_1 - \mu_2 \neq 0$. As some fraud companies have been delisted after they committed fraud, there are only 14 out of 18 paired companies that can be used to conduct the t-test. Besides, for this t-test we still choose $\alpha = 0.05$ as the significance level.

5.2. Data Collection & Calculations

The table 7 displays the average score of years before the fraud and the average score of years after fraud has been calculated. Then, the absolute value of $AVG_{fraud\ before} - AVG_{fraud\ after}$ is calculated and used as data for t-test.

Table 7: Summarized M-Score, F-Score, change of score data table.

Years	Experimental group						Control group					
	M-Score	AVG	$\|change\|$	F-Score	AVG	$\|change\|$	M-Score	AVG	$\|change\|$	F-Score	AVG	$\|change\|$
1	Link Motion NQ						Renren RENN					
2010	1.104	1.104	3.347	0.302	0.302	1.434	-2.839	-2.839	0.208	0.036	0.036	2.248
2013	-2.212	-2.243		1.685	1.736		-2.415	-3.047		2.913	2.284	

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Table 7: (continued).

2014	-1.914			2.052			-1.049			2.997		
2015	-2.272			1.328			-6.280			1.676		
2016	-2.574			1.880			-2.443			1.550		
2	China-Biotics CHBT						Sinovac Biotech SVA					
2008	-3.017	-2.975	3.457	0.354	0.420	0.378	-2.190	-2.488	0.442	0.838	0.685	0.177
2009	-2.932			0.486			-2.785			0.532		
2012	4.019	0.482		0.996	0.798		-1.970	-2.046		0.493	0.508	
2013	-3.005			0.599			-2.122			0.522		
3	Focus Media FMCN						Sina SINA					
2007	-1.913	-3.079	0.525	2.460	1.541	0.402	-2.609	-2.260	0.123	0.917	0.976	0.527
2008	-4.768			2.471			-2.396			0.876		
2009	-3.356			0.501			-1.726			0.747		
2010	-2.277			0.733			-2.334			1.364		
2012	-2.554	-2.554		1.139	1.139		-2.383	-2.383		1.503	1.503	
4	JinkoSolar JKS						Dargo New Energy DAQO					
2016	0.965	0.965	3.508	3.068	3.068	0.932	-2.829	-2.829	0.289	0.482	0.482	0.328
2018	-2.934	-2.543		2.291	2.136		-1.854	-2.540		0.623	0.810	
2019	-2.710			2.178			-4.045			0.659		
2020	-2.455			2.111			-2.646			0.637		
2021	-2.073			1.962			-1.614			1.321		
5	Akso Health Group AHG						Tarena International TEDU					
2017	-2.785	-2.785	3.097	0.483	0.483	1.377	-3.741	-3.741	0.371	0.643	0.643	0.031
2020	-5.882	-5.882		1.860	1.860		-4.112	-4.112		0.674	0.674	
6	TAL Education						Rise Education Group					
2017	-3.198	-3.198	0.239	1.323	1.323	0.311	-2.306	-2.306	0.328	0.463	0.463	0.593
2019	-3.276	-2.959		1.030	1.012		-2.362	-2.634		0.941	1.056	
2020	-2.641			0.993			-2.945			1.171		
7	Global Data Solutions Limited GDS						Splunk SPLK					
2017	-1.730	-1.730	0.428	0.554	0.554	0.015	-3.741	-3.741	1.014	1.158	1.158	0.165
2021	-2.158	-2.158		0.569	0.569		-2.727	-2.727		0.993	0.993	
8	Beigene BGNE						United Therapeutics Corporation UTHR					

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Table 7: (continued).

2016	-4.143	-4.143	1.559	5.149	5.149	4.113	-2.119	-2.119	0.445	0.580	0.580	0.481
2019	-2.310	-2.584		0.670	1.036		-2.721	-2.564		1.023	1.061	
2020	-2.349			1.897			-2.702			0.989		
2021	-3.094			0.541			-2.268			1.171		
9	Uxin UXIN						Cango CANG					
2017	-0.267	-0.267	8.952	1.613	1.613	0.764	-2.568	-2.568	0.555	2.461	2.461	0.766
2020	-9.219	-9.219		0.849	0.849		-2.013	-2.013		1.695	1.695	
10	Hello Group MOMO						Sohu.com SOHU					
2015	-1.049	-1.049	2.434	2.007	2.007	1.885	-3.467	-3.467	0.394	1.166	1.166	0.648
2018	-3.483	-3.483		4.846	3.892		-3.082	-3.082		1.702	1.814	
2019	/			2.938			/			1.925		
11	Pinduoduo PDD						JD.com					
2017	-3.727	-1.673	0.852	1.425	3.141	1.033	-2.973	-2.993	0.643	1.497	1.329	0.022
2018	0.382			4.857			-3.013			1.160		
2020	-2.525	-2.525		2.108	2.108		-2.350	-2.350		1.351	1.351	
12	LexinFintech LX						Fanhua FANH					
2017	-2.225	-3.037	0.718	0.067	0.461	1.525	-2.332	-2.924	0.500	1.371	1.143	0.785
2018	-3.848			0.854			-3.516			0.915		
2021	-2.319	-2.319		2.680	1.986		-2.424	-2.424		1.290	1.928	
13	IQiyi IQ						Bilibili BIU					
2018	-3.541	-3.541	1.106	5.052	5.052	3.393	-2.544	-2.544	0.100	1.529	1.529	0.678
2021	-2.435	-2.435		1.659	1.659		-2.444	-2.444		2.207	2.207	
18	Canaan CAN						21 Vianet VNET					
2018	5.908	-0.277	1.055	1.173	1.628	0.741	-2.941	-2.796	0.241	0.582	0.676	0.129
2019	-6.462			2.082			-2.650			0.769		
2021	-1.332	-1.332		0.887	0.887		-3.037	-3.037		0.805	0.805	

5.3. T-test Result & Analysis

5.3.1. M-score Result

Calculated data from the table above, we get test statistic=2.66646 and the critical value is 2.16037 at df=13 and $\alpha = 0.05$. Therefore, H_0 can be rejected.

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5.3.2. F-score Result

Calculated data from the table above, we get test statistic=2.42374 and the critical value is 2.10092 at df=18 and $\alpha = 0.05$. Therefore, H_0 can be rejected.

5.3.3. Result Analysis

The rejection of the null hypothesis of both M-score and F-score indicates that companies could not return to normal after committing fraud as there exist disparities in scores between them and their industries. This suggests that committing fraud has long-term effects on companies' sales, earnings, assets, etc. Therefore, fraud has not only harmed companies' stakeholders such as investors and suppliers, but also the firms themselves. As a result, the causes of fraud should be carefully analyzed, and measures should be taken to prevent fraud.

6. Causes, Motives, and Prevention of Fraud

6.1. Methods and Motives of Fraud

The financial fraud problem of Chinese companies has triggered massive shorting in the market, and many Chinese companies have been forced to go private due to pressure. The reason why Chinese concept stocks are concentrated on shorting is related to the over-packaging and fabrication of financial statements by Chinese companies during their overseas listing process, taking advantage of the differences in accounting standards between the U.S. and China [45]. The table 8 below summarizes all the fraudulent practices of companies in our sample.

For example, GDS limited company took advantage of the difference in accounting accounts between the United States and China, which allowed the company to cascade its liabilities into reported revenue. As a result, the financial statements show a significant difference between PPE (fixed assets) and construction spending levels. The company spent money building the data center, but there is no record of new equipment purchases. The supplier can change the invoice amount, generating revenue out of thin air if the amount exceeds the actual expenditure. At the same time, data center maintenance and renovation costs are recognized as "long-term prepayments", which is considered an account used only in Chinese statements.

Table 8: Financial fraudulent practices of the company.

Universal travel group	1. Hide employee salary expenses 2. Overstated assets (cash accounts) 3. Inflated the company's sales revenue through insufficient online booking 4. Unnecessary fundraising and costly acquisitions dilute shareholder equity
Focus Media Holding Ltd.	1. Fraudulently overstating the number of screens in its LCD network (overstating assets) 2. Misrepresented acquisition of insider's company at a high premium (insider trading)
Pinduoduo Inc.	1. The distortion of Gross Merchandise Volume amount through cancellation of orders.
Fushi Copperweld Inc.	1. Overstated revenue through inflating factory output volume

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Table 8: (continued).

Akso Health Group	1. Overstated accumulated revenue to attract investors 2. Misappropriation of assets
JOYY	1. Overstated revenue from Live Streaming reward data
GDS Holdings Limited	1. Overstated revenue by at least 25% through transferring a portion of capital expenditures to revenue 2. Inflated asset acquisition prices 3. Capital expenditures are not invested in actual operations
UXIN	1. Overstated revenue by exaggerated car sales by 40% 2. Excessive debt
China-Biotics Inc.	1. Shell Listing and Shell trader takes 35% equity 2. Fake business operations, many sales stores do not exist
TAL Education	1. Overstated sales revenue and contributed to 4% increasing in total revenue
BeiGene	1. Falsify reported 60% of sales revenue 2. Liabilities undertaken by shell company and raised capital on shell company
Link Motion	1. Overstated sales revenue and number of users 2. Made fraud on cash and cash equivalents
HelloGroup MOMO	1. Overstated the number of active users
Iqiyi Inc.	1. Inflated expenses, sales revenue and other assets 2. Overstated the user numbers by 42% to 60%
58 Inc.	1. Inflated sales revenue
Canaan Inc.	1. Inflated sales revenue quarterly
Lexin	1. Overstated the user numbers
JinkoSolar	1. Overstated sales revenue 2. Undisclosed existed liabilities

From the above analysis of our existing financial fraud companies, it can be found that most of the companies do their tricks from their financial statements, mainly by inflating profits, inflating results, hiding expenses, exaggerating assets, manipulating transactions, overstating users through related parties and other ways to commit financial fraud, to achieve the purpose of conveying wrong information that is not easy to identify to outside users and attracting investors. The causes of falsification could be divided into two sides. From the internal causes, this often confirms the weaknesses of management and corporate governance structures and weak internal and external supervision mechanisms. In addition, the high-frequency change of independent auditors and Chinese companies' inconsistency in filings submitted to SEC and Chinese regulators could be warning signals from external [46].

6.2. Fraud Prevention

According to the fraud triangle model, an explanatory framework for financial fraud, three variables contribute to financial fraud behavior: motivation, opportunity, and rationalization [47]. Therefore, in order to lower the likelihood of committing financial fraud, steps should be taken to diminish the

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presence of motivation, opportunity, and rationalization.

6.2.1. Measures to Reduce Motivation

Increase the penalties for conducting financial fraud: Meeting the earnings benchmark is the most important indicator for company managers because they want to show a better business result to the public [48]. Therefore, they will try to achieve the expected EPS value, where fraud is created because the cost of fraud is less than the benefit of fraud, so the company will violate the code of ethics. Therefore, increasing the penalties of conduct can effectively decrease the incentive of committing fraud and all those involved in the process should be punished to the appropriate degree.

6.2.2. Measures to Reduce Opportunity

Strengthen the cooperation of cross-border audit regulation between China and the U.S.: The differences in audit approaches and regulatory standards between China and the U.S. can allow some companies to commit fraud. Therefore, both sides need to coordinate reasonable regulatory standards, and cooperation between the two sides can improve the efficiency of regulation. In addition, the auditors themselves play the role of 'gatekeepers' of the capital market and need to perform their duties of objectivity, fairness and diligence in their work and their responsibility to maintain fairness and integrity in the capital market. Therefore, the laws and regulations concerning their code of ethics should be continuously improved.

Increase the amount of peer review for firms: Current auditors have fewer incentives to do peer reviews since it is not worth the time to double-check paper items or they have no incentives to criticize their colleagues. However, peer evaluations can increase audit quality since existing auditors are better familiar with the responsibilities and hence more equipped to evaluate their colleagues. Thus, in order to increase audit quality, governments or the SEC should implement laws that encourage auditors to participate in peer review.

Introduction of big data statistics: The introduction of big data auditing not only could save audit costs and energy and prevent the problem of math errors or fraud zones brought about by traditional auditing. Moreover, the relevant people have clearly defined authorization and could trace to work. So there is more objective and accurate supervision of the actual operation of the company.

Promote voluntary disclosure: Voluntary disclosure can improve the information environment by disclosing more transparent information than mandatory disclosure, reducing companies' opportunities to commit fraud [49].

6.2.3. Measures to Reduce Rationalization

Improving employee whistleblowing mechanisms: Some restrictions in business often require subordinates to follow superiors. In this situation, employees will certainly choose the best option in their best interests when selecting between passive fraud and anonymous reporting of internal and external reporting mechanisms are widely promoted. Moreover, adopting such a company-wide strategy can improve the company's general environment so that employees are more inclined to conduct ethically in their financial reporting rather than engage in others' fraudulent behavior, resulting in the management's better use of power rather than abuse.

7. Conclusion

In this work, we plan to verify that M-Score and F-Score models effectively indicate accounting fraud. By conducting two t-tests, we come to the preliminary conclusion that the two models are both capable of implying manipulation in the statistical significance which applies to Chinese companies

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listed in the U.S. Based on the preliminary conclusion, we effectively demonstrate that the fraudulent companies suffer long-term consequences as a result of the fraudulent events by doing another t-test. However, the data and statistical models we used still have some limitations and randomness. In the future, it is possible that more scholars will delve deeper into the study and verify it by other methods to obtain more accurate results. We look forward to future research on this topic.

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