

# Anything wrong with breaking a buck? An empirical evaluation of NASDAQ's \$1 minimum bid price maintenance criterion<sup>☆</sup>

S. Ghon Rhee<sup>a</sup>, Feng Wu<sup>b,\*</sup>

<sup>a</sup>*Shidler College of Business, University of Hawaii at Manoa, 2404 Maile Way, Honolulu, HI 96822, USA*

<sup>b</sup>*Faculty of Business Administration, University of Macau, Av. Padre Tomás Pereira, Taipa, Macau*

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## Abstract

This paper empirically evaluates the effects of NASDAQ's \$1 minimum bid price threshold (known as the *one-dollar rule*) as part of its listing maintenance criteria. Even though this controversial rule was introduced as early as September 1991, its economic impact has been largely unexplored by academics. This study suggests that implementation of the one-dollar rule is justified for the following reasons: (1) NASDAQ stocks frequently trading below \$1 during the pre-rule period are extremely vulnerable to catastrophic losses; (2) a dramatic decline in extreme loss probability is observed among low-priced (relative to \$1) stocks after the rule was introduced; and (3) the \$1 benchmark serves as an appropriate cutoff point in screening stocks listed on the exchange.

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\*Corresponding author.

*E-mail addresses:* [rheeg@hawaii.edu](mailto:rheeg@hawaii.edu) (S.G. Rhee), [fengwu@umac.mo](mailto:fengwu@umac.mo) (F. Wu).

## 1. Introduction

Major stock exchanges are exclusive “clubs,” each with its own listing maintenance criteria. The reputation and viability of an exchange depend on the companies it lists. Listing requirements have evolved throughout the history of stock exchanges. In the past two decades, one particular practice is setting an arbitrary minimum trading price for listed companies. Major exchanges in the United States have adopted minimum price rules. The NYSE has a \$1 average closing price criterion in its continued listing standards.<sup>1</sup> The NASDAQ Stock Market (NASDAQ hereafter) requires a listed company’s shares to close above \$1 (bid price) at least once over a consecutive 30-business-day period, which is known as the minimum bid price rule (or the *one-dollar rule*). A grace period is allowed for listed issuers breaking the one-dollar rule to provide a buffer of time within which to catch up, but the stock is delisted if higher-than-\$1 bids cannot be restored during the grace period. This rule applies to all three NASDAQ component markets: the Global Select Market, the Global Market, and the Capital Market. Appendix A summarizes the maintenance requirements for listed companies on these markets.<sup>2</sup> On the NASDAQ, security delistings due to non-compliance with the minimum bid price criterion account for almost 42% of all regulatory delistings.<sup>3</sup> This makes the one-dollar rule the most critical requirement among all maintenance standards. In contrast to these two U.S. exchanges, most equity markets outside the U.S. do not institute a minimum price criterion for maintaining listing.<sup>4</sup>

An extreme non-U.S. case happened in Hong Kong on July 25, 2002, when the Hong Kong Exchanges and Clearing Limited (HKEx) released a consultation paper that proposed the delisting of penny stocks from the Main Board if the moving average of daily volume-weighted share price was less than HK\$0.5 (about US\$0.065) over 30 consecutive trading days.<sup>5</sup> The following day, market capitalization of penny stocks collapsed by approximately HK\$10.91 billion (about US\$1.4 billion), with daily price dropping by as much as 88%. This forced the HKEx to withdraw the proposal two days later. On November 12, 2002, HKEx reversed its position on the minimum price criterion by announcing that it “would like the views of a wider audience on whether there should be any minimum (price) standards for continuing listing.”<sup>6</sup>

<sup>1</sup>NYSE Listed Company Manual, Section 802.01C, from [www.nyse.com](http://www.nyse.com). Refer to Appendix B for details.

<sup>2</sup>The minimum price criterion is more common in the *initial* listing standards of U.S. exchanges such as the NYSE, the NASDAQ, the former American Stock Exchange (currently known as the NYSE Amex), the former Boston Stock Exchange (currently known as the NASDAQ OMX BX), the former Philadelphia Stock Exchange (currently known as the NASDAQ OMX PHLX), and the NYSE Arca (which also has a \$1 minimum price rule in its continued listing standards).

<sup>3</sup>These statistics are compiled during the period from September 1, 1991 to December 31, 2009. Refer to Panel A of Table 2 for details.

<sup>4</sup>Only two Asian exchanges in Korea and Indonesia have a minimum price requirement in their continued listing standards. The Neuer Markt in Germany also had a similar rule before its closing in 2003.

<sup>5</sup>Hong Kong Exchanges and Clearing Limited, 2002, “Consultation paper on proposed amendments to the listing rules relating to initial listing and continuing listing eligibility and cancellation of listing procedures,” from [www.hkex.com.hk/news/hkexnews/020725news.htm](http://www.hkex.com.hk/news/hkexnews/020725news.htm).

<sup>6</sup>Hong Kong Exchanges and Clearing Limited, 2002, “HKEx today released its revised consultation paper on Continuing Listing Criteria and Related Issues,” from [www.hkex.com.hk/news/hkexnews/021115news.htm](http://www.hkex.com.hk/news/hkexnews/021115news.htm).

Obviously, HKEx is not the only exchange with these concerns. On U.S. markets, debates about the minimum bid price standard have lasted for two decades since the NASDAQ first introduced the one-dollar rule in September 1991. The Securities and Exchange Commission (SEC) and the Financial Industry Regulatory Authority (FINRA) support the rule.<sup>7</sup> In contrast, many Wall Street law firms, issuers, and securities companies do not agree with the underlying rationale of the rule. The regulators claim that the minimum bid price standard “generally serve(s) to increase investor confidence and the credibility of (the) market.”<sup>8</sup> The opponents, on the contrary, harshly criticize the policy. Arguments such as “the \$1 rule doesn’t really make any sense,” “it is a dubious measure even in the best of times,” “I always thought the rule was a strange rule” are not uncommon in the media and among industry practitioners.<sup>9</sup>

Despite widespread application of minimum price listing requirements on U.S. stock exchanges and long-lasting disputes between market participants and regulators, academics have been silent on this issue. “This academic silence (relatively speaking, at least) on the role of quantitative listing standards is puzzling, considering the important role such standards play in determining the set of securities to which qualitative exchange regulation will apply” (Harris, 2006, p. 239). According to Bottazzi and Da Rin (2005, p. 24), “there is an obvious need to evaluate how different rules perform in terms of selecting valuable companies.” To the best of our knowledge, however, no rigorous academic research has been conducted to examine this controversial listing standard. All evidence cited in this regard has been anecdotal. As Seguin and Smoller (1997, p. 334) point out, “exchange and regulatory officials admit that the share price cutoff ... is based primarily on popular perceptions rather than on theoretical or empirical evidence.” Hence, the use of price as a discriminatory variable for listing maintenance requires justification.

Recent developments on U.S. markets make this issue more interesting than ever. Amidst the recent global financial crisis, the NASDAQ temporarily suspended its minimum bid price rule for listed companies as of October 16, 2008 and then extended the deadline of the suspension to July 31, 2009.<sup>10,11</sup> The NYSE adopted a similar approach in February 2009 and temporarily suspended the minimum closing price rule through the end of July 2009. Such practices reflect important adjustments of minimum price related listing standards on major U.S. exchanges. To appraise these adjustments, however, one needs to evaluate how effective the minimum price rule is in the first place.

This paper examines the effects of the minimum bid price maintenance rule on the NASDAQ markets. The choice of NASDAQ-listed issues is justified because of a large number of stocks trading below \$1. We focus on price collapses (catastrophic losses) of individual stocks since they can swiftly wipe out immense market value and severely

<sup>7</sup>The FINRA was created in July 2007 through the consolidation of the National Association of Securities Dealers (NASD) and the member regulation, enforcement, and arbitration functions of the NYSE.

<sup>8</sup>62 *Federal Register*, 17269.

<sup>9</sup>Quotations are from Kennedy, S., 2001, “NASDAQ mulls waiver of \$1 delisting rule,” from [www.us.rediff.com/money/2001/sep/26nasdaq.htm](http://www.us.rediff.com/money/2001/sep/26nasdaq.htm), Glassman, J., 2003, “Nothing wrong with breaking a buck,” *Jewish World Review*, February 3, 2003, from [www.jewishworldreview.com/cols/glassman020303.asp](http://www.jewishworldreview.com/cols/glassman020303.asp), and Krantz, M., 2001, “NASDAQ suspends \$1 listing rule: techs may benefit,” from [www.usatoday.com/tech/techinvestor/2001/09/28/nasdaq-listing-rule.htm](http://www.usatoday.com/tech/techinvestor/2001/09/28/nasdaq-listing-rule.htm), respectively.

<sup>10</sup>The NASDAQ reports that the number of its listed companies trading below \$1 per share increased from 64 on September 30, 2007 to 334 on October 9, 2008.

<sup>11</sup>The NASDAQ imposed a similar suspension after the 9/11 attacks in 2001. Refer to Section 2.1 and Appendix B for details.

damage public confidence in the market. Low-priced securities are more susceptible to extreme price drops. They are also more likely to be the targets of speculative activities.<sup>12</sup> In this study, we employ an extreme value approach to demonstrate the vulnerability of low-priced stocks to catastrophic losses. Since sharp price declines take place around the far left tail of return distribution, we derive from the Generalized Extreme Value (GEV) model a market-adjusted extreme tail risk measure (also called probability of extreme loss or extreme loss probability in this paper) to examine return behaviors of low-priced securities.<sup>13</sup> Specifically, we compare extreme tail risk across stocks at different price levels before and after the one-dollar rule is implemented. As a classical model in the Extreme Value Theory (EVT), which specifically describes the unusual outcomes, GEV distribution delivers an informative measure of the probability of price collapse, and comparisons of extreme loss probability are a useful vehicle for assessing the effects of the minimum bid price requirement.

Empirical evidence compiled in this study suggests that implementing a minimum price benchmark is justified. On the NASDAQ, before the introduction of the one-dollar rule, average extreme loss probability associated with stocks frequently trading below \$1 is over 14 times larger than that of other stocks frequently trading above \$1. Subsequent to the adoption of the rule, average extreme loss probability of “under \$1” stocks is substantially diminished (an over 88% decrease).<sup>14</sup> The huge decline suggests that the magnitude and frequency of dramatic price collapses in low-priced (relative to \$1) securities trading on the NASDAQ are largely reduced after the application of the minimum bid price standard. The impact of the one-dollar rule is further manifested by the fact that extreme tail risk of more likely to break \$1 stocks exhibits significant increases relative to “above \$1” stocks during the rule-suspension periods. Moreover, traditional risk indicators such as standard deviation, skewness, and kurtosis do not show similar inter-period dynamics as the extreme tail risk. This reinforces our belief that the GEV-based extreme loss probability represents an informative tool for detecting catastrophic risk.

As robustness checks, we differentiate penny stocks and fallen angels (stocks that trade at high prices and then drop below \$1) to examine whether their tail risks differ. We observe that average extreme tail risk is lower for fallen angels but inter-period risk characteristics are similar between the two groups. We also conduct further analyses on stocks frequently trading above \$1, and find that the “distance” to \$1 determines a stock’s extreme tail risk: the closer to \$1 the stock price, the larger the risk is. Despite this observation, stocks with prices falling into ranges higher than \$1 generally do not show as extraordinarily large extreme tail risk as “under \$1” stocks in the pre-rule period. This provides supporting evidence that the \$1 benchmark is an appropriate cutoff in screening stocks listed on the exchange.

The remainder of this paper is organized as follows: [Section 2](#) provides institutional background and a review of the literature related to exchange listing standards and share price; [Section 3](#) introduces research design, the GEV model, and data sampling; [Section 4](#) explores the extreme tail risk of stocks frequently trading below or above \$1 across

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<sup>12</sup>According to an estimation made by the North American Securities Administrators Association in September 1989, Americans lose at least \$2 billion each year as a result of schemes involving penny stocks. See 56 *Federal Register*, 44109.

<sup>13</sup>More precisely, probability of extreme loss (or extreme loss probability) should refer to extreme *left* tail risk. We call it extreme tail risk for simplicity.

<sup>14</sup>In this paper, wherever no confusion arises, we use “under \$1” stocks to refer to securities frequently trading below \$1 or more likely to break \$1, and use “above \$1” stocks to refer to securities frequently trading above \$1 or less likely to break \$1, as defined in [Section 4](#).

different periods, describes inter-period changes of standard risk indicators, and demonstrates the uniqueness of GEV-based measure in reflecting extreme downside risk; [Section 5](#) conducts additional examinations on extreme tail risk of penny stocks, fallen angels, and stocks in other price-based portfolios; [Section 6](#) concludes.

## 2. Institutional background and related literature

### 2.1. Evolution of the one-dollar rule

The NASDAQ minimum bid price listing requirement originated from a series of broad-based programs initiated and supervised by the SEC. The reforms targeted at low-priced securities that trade largely on the OTC markets. In 1988 and 1990, the SEC respectively approved Schedule H of the NASD Bylaws and adopted Rule 15c2-6 under the Securities Exchange Act of 1934 (SEA) to require broker-dealers to report their daily transaction volume and dispense with penny stock warnings to investors.<sup>15</sup> Also in 1990, the SEC, the North American Securities Administrators Association, and some state regulators prompted further regulatory reforms that led to the Securities Enforcement Remedies and Penny Stock Reform Act of 1990 (PSRA), which requires broker-dealers selling certain low-priced securities to obtain a written sales agreement from any purchaser who is not a regular customer.<sup>16</sup>

However, provisions of the aforementioned rules or acts do not apply to NASDAQ securities. This created an incentive for low-priced security issuers to circumvent the compliance by seeking NASDAQ authorization. In January 1990, the SEC wrote to the NASD urging it to carefully scrutinize NASDAQ listing applications to ensure that low-priced securities fully complied with all applicable standards.<sup>17</sup> The NASDAQ responded with a proposal on April 9, 1990 to raise its listing standards by, amongst other things, adopting for the first time a requirement that U.S. and Canadian issuers maintain a minimum bid price. The proposal was officially approved by the SEC on August 30, 1991.

The PSRA also mandated the establishment of an automated quotation system for OTC equity securities, which led to the creation of the OTC Bulletin Board (OTCBB) on June 1, 1990.<sup>18</sup> The OTCBB served many small companies that did not qualify to keep their shares listed on the NASDAQ because of the more stringent maintenance criteria.

NASDAQ's original bid price rule allowed for a perpetual exemption from the \$1-minimum if certain public float and capital and surplus requirements were met.<sup>19</sup> This alternative compliance option was abandoned in 1997 when the NASDAQ decided to adopt firm maintenance of the \$1 bid price maintenance rule. Such a policy lasted until

<sup>15</sup>Refer to 53 *Federal Register*, 16488 and 54 *Federal Register*, 35468, respectively.

<sup>16</sup>*Pub. L.* 101-429, 104 *Stat.* 931 (October 15, 1990).

<sup>17</sup>56 *Federal Register*, 44111.

<sup>18</sup>Besides the OTCBB, a large part of non-NASDAQ OTC securities trade on the OTC Markets Group. Unlike the OTC Markets Group, companies quoted on the OTCBB must be current with all required SEC filings, which provides more transparency on the OTC equity markets.

<sup>19</sup>For the SmallCap Market (currently known as the Capital Market), an issuer could use the exemption if the market value of its public float was at least \$1 million and it had capital and surplus of at least \$2 million. For the National Market (currently known as the Global Market), an issuer could use the exemption if market value of its public float was at least \$3 million and it had capital and surplus of at least \$4 million. See 69 *Federal Register*, 6709.

September 27, 2001 when the NASDAQ suspended the one-dollar rule through the year-end under pressure of the economic slump after the 9/11 attacks. Immediately after the moratorium, the NASDAQ initiated a three-year pilot program, aiming to revise the length of grace period. Before the 9/11 shocks, the grace period was 90 calendar days for both the NASDAQ National Market (currently known as the Global Market) and the SmallCap Market (currently known as the Capital Market). During the pilot program, the NASDAQ proposed several amendments to extend the grace period, with the longest one reaching a maximum of two years for SmallCap issuers. The two-year maximum grace period, however, was cut in half to 360 calendar days following the end of the pilot program. Moreover, non-Canadian foreign issuers on the Capital Market were also subject to the same \$1 minimum bid price requirement effective from May 29, 2006.<sup>20</sup> On October 16, 2008, as a response to the turmoil on U.S. and world financial markets, the NASDAQ once again implemented a temporary suspension of the one-dollar rule. The suspension remained in effect through July 31, 2009. Notably, the NASDAQ has been making efforts to have the rule more consistently and universally applied, while providing flexibilities to issuers experiencing difficulties. [Appendix B](#) provides a chronological list of events related to reforms of OTC markets and the minimum price maintenance rules.

The NASDAQ claims that it “continues to believe that the bid price requirements are a valuable measure of compliance.”<sup>21</sup> However, to our knowledge, justifications for the rule that regulators could provide are based exclusively on perceptions gathered from anecdotal evidence. Interestingly, in Rule 15c2-6 under the SEA, the SEC sets \$5, rather than \$1, as benchmark price for the definition of penny stock. It claims that the \$5 price “is consistent with the Uniform Limited Offering Registration project developed by the State Regulation of Securities Committee of the American Bar Association to provide a short-term registration procedure for small business private offerings.”<sup>22</sup> Obviously, this is more of a legitimate concern than a market concern, and says nothing about the \$1 benchmark. Similarly, the NASDAQ originally seemed uncertain about the exact level of the minimum bid price threshold. Along with the introduction of the one-dollar rule, it included a \$3-minimum under Standard 2 of the continued listing requirements for National Market issuers. This elevated price cutoff was replaced by the \$1 benchmark in March 2003, because the NASDAQ did not believe that any additional material protection was afforded to investors as the result of the \$3 bid price requirement.<sup>23</sup> Despite all statutory bases and rule changes, assessing the suitability of the minimum price rule remains an unresolved empirical issue.

## 2.2. Literature related to exchange listing standards and share price

Exchange listing standards are partially rooted in an adverse selection problem caused by information asymmetry. [Harris \(2006\)](#) refers to [Akerlof's \(1970\)](#) “lemons problem” to explain exchanges’ incentives for maintaining their reputation by screening issuers and accepting only

<sup>20</sup>For detailed information, refer to SEC Release No. 34-47482; File No. SR-NASD 2003-34, SEC Release No. 34-48991A; File No. SR-NASD 2003-44, SEC Release No. 34-50541; File No. SR-NASD 2004-147, SEC Release No. 34-50753; File No. SR-NASD 2004-147, [www.nasdaq.com/about/ForeignListingStandards021105.pdf](http://www.nasdaq.com/about/ForeignListingStandards021105.pdf), and [www.perkinscoie.com/content/ren/updates/corp/delisting.htm](http://www.perkinscoie.com/content/ren/updates/corp/delisting.htm).

<sup>21</sup>68 *Federal Register*, 12731.

<sup>22</sup>56 *Federal Register*, 17193.

<sup>23</sup>68 *Federal Register*, 12732.

qualified applicants. Without an appropriate screening mechanism, above average quality issuers exit the market, leading to a decline in average quality of the remaining companies until the market eventually ceases to exist. A good example is the fall of the AMEX Emerging Company Marketplace (ECM). In sharp contrast to NASDAQ's success, the ECM had a short life of slightly over three years (from March 18, 1992 to May 11, 1995). Aggarwal and Angel (1999) examine the reasons for the failure of the ECM. They find that successful ECM issuers quickly departed for senior markets, leaving only unsuccessful firms behind. Chemmanur and Fulghieri (1999, p. 272) suggest that imposing listing standards “leads to an upper bound on the variance ... of the true value of the firm whose equity is listed, and is consequently desirable for exchanges seeking to control this variance.” In a theoretical model, Chemmanur and Fulghieri (2006) demonstrate that listing standards chosen by exchanges affect their reputation and that the competition between exchanges will not necessarily lead to a “race to the bottom” in listing criteria. A similar idea is expressed by Huddart, Hughes, and Brunnermeier (1999) and Santos and Scheinkman (2001). Macey and O'Hara (2002), however, cast much doubt on implementing stringent listing standards. They propose dropping listing requirements altogether, because the information-conveying functions of exchanges are diminishing. Similarly, in a study of the NASDAQ delisting effect, Harris, Panchapagesan, and Werner (2008) recommend that the NASDAQ consider easing non-core listing requirements (including the minimum bid price standard) because the cost of enforcing minor criteria overweighs the benefit. Among the few studies of price criteria, most focus on initial, rather than continued, listing standards, and the general conclusion is that a higher IPO price is associated with a lower rate of mortality (Seguin and Smoller, 1997; Fama and French, 2004; Fernando, Krishnamurth, and Spindt, 2004; Bradley, Cooney, Dolvin, and Jordan, 2006).

Some studies examine the tactics that companies can utilize to avoid violating the minimum price rule. Reverse stock split (RSS) is one commonly adopted method of raising share price above \$1, which is allowed by the NASDAQ. However, negative market responses to announcements of RSS on U.S. markets are reported by a number of papers (Peterson and Peterson, 1992; Han, 1995; Desai and Jain, 1997; Nelling and Chen, 2003; Martell and Webb, 2008). A broadly accepted explanation for these findings is that RSS signals to the market that management has either lost confidence in future price increases or exhausted all other means of maintaining the listing. RSS is the last straw before a stock is delisted to less liquid and less transparent markets, which becomes especially apparent after the NASDAQ introduced the one-dollar rule.<sup>24</sup> In Canada, however, RSS is associated with *positive* market responses, as documented by Masse, Hanrahan, and Kushner (1997). This is interesting because Canadian exchanges do not impose minimum price maintenance requirement. So the market's awareness of the existence of minimum price criteria largely limits the effectiveness of RSS as a way of circumventing the legislation. This highlights the unavoidable impact of the one-dollar rule on issuers with low-priced stocks.

Overall, as Harris (2006, p. 240) emphasizes, “listing standards appear ... to matter. Analysing the incentive structure within which listing standards are set presents a novel opportunity to analyse stock exchange regulation more generally.” However, little academic research has been conducted on evaluation of listing standards, especially the *continued* listing standards. This paper is the first effort to evaluate the NASDAQ

<sup>24</sup>Sharp drops of price and dramatic reductions of liquidity upon delisting have been documented (Sanger and Peterson, 1990; Lamba and Khan, 1999; Chandy, Sarkar, and Tripathy, 2004; Macey, O'Hara, and Pompilio, 2008).

one-dollar rule. The findings should provide guidance for the regulatory activities on other exchanges, which have not adopted or are considering adopting similar rules.

### 3. Research design, model, and data sampling

#### 3.1. Research design

In Schedule 15G under the SEA, the SEC requires that brokers of low-priced securities warn clients that “investors in penny stock should be prepared for the possibility that they may lose their whole investment.”<sup>25</sup> This reflects the fact that unusual extreme price collapses are more common among low-priced stocks.<sup>26</sup> If investors frequently witness fast evaporation of their investment, they lose confidence in the trading markets, which threatens the legitimacy of the securities industry. If an exchange is riddled with listed securities that are suffering from extensive and sharp price drops, its reputation will be severely damaged. Furthermore, if extreme value losses cluster in stocks priced below a certain low level, necessary regulatory actions should be required. Therefore, examining extreme price collapses is one approach to assessing the minimum price rule. In this sense, the far left end of return spectrum is of great importance for regulatory purposes, and the tail behavior can provide investors with new insights about extreme risk. Specifically, if stocks with prices lower than the threshold level (lower than \$1 for NASDAQ issuers) exhibit extraordinary price drops (i.e., unusually high extreme tail risk), they may be deemed harmful to investors’ interests and the market’s integrity. Moreover, the regulation can be considered effective if extreme tail risk of low-priced (relative to \$1) stocks becomes significantly lower after the minimum price standard is imposed. Finally, if a pre-determined price level (e.g., \$1 as set by the NASDAQ) performs better than other cutoff points in distinguishing securities with high extreme tail risk from other stocks, it can be considered a good threshold in the minimum price rule.

We utilize the EVT model to detect extreme price plummets. Specifically designed to assess the shape of the far end of a random process, EVT is a well-established statistical discipline that quantifies the probabilistic nature of unusually large changes and is especially suitable for the study of extreme tail risk associated with low-priced stocks. Under appropriate conditions, relevant information about extreme loss probability can be incorporated into an inference under the EVT framework to facilitate our analyses.

#### 3.2. Extreme value model setup

Analogous to the Central Limit Theorem describing asymptotic characteristics of sample means, EVT prescribes asymptotic distribution of sample extrema, i.e., the maxima

<sup>25</sup> Refer to [www.sec.gov/investor/schedule15g.htm](http://www.sec.gov/investor/schedule15g.htm) for more information.

<sup>26</sup> A vivid example is Comparator Systems (a former NASDAQ SmallCap issuer). On May 7, 1996, the share price of Comparator was pumped from a few cents to a high of nearly \$2, followed by a swift price decline to 56 cents before the NASDAQ halted trading in Comparator prior to market open on May 9, 1996. Comparator was delisted from the NASDAQ on May 14, 1996. Note that the Comparator case occurred after the NASDAQ adopted the one-dollar rule. However, the company was exempted from satisfying the minimum bid price standard by meeting the capital surplus alternative. Actually, in the year following this case (1997), the NASDAQ removed the exemption and enforced the one-dollar rule on all domestic and Canadian issuers. See Section 2 and Appendix B for details.

or minima. EVT estimates are robust to the initial distribution of the population, which makes it a powerful tool for analyzing risk in tails. In this study, we utilize the GEV model, which is a classical parametric EVT method with nice asymptotic properties. This model shows that standardized extrema of a random series converge to a single GEV distribution.

For an i.i.d. sequence of  $n$  random variables  $\{X_1, X_2, \dots, X_n\}$ , let  $R_n$  denote the minimum of this sample.<sup>27</sup> Suppose there exist sequences of constants  $\{\mu_n\}$  and  $\{\psi_n > 0\}$  such that the normalized random variable  $(R_n - \mu_n)/\psi_n$  has a non-degenerate limiting cumulative distribution function  $H(r)$  as  $n \rightarrow \infty$ , then  $H(r)$  must belong to one of the following families (Fisher and Tippett, 1928; Gnedenko, 1943):<sup>28</sup>

$$\begin{aligned} \text{Gumbel type : } H(r) &= 1 - \exp \left[ -\exp \left( \frac{r - \mu}{\psi} \right) \right], \psi > 0; \\ \text{Fréchet type : } H(r) &= \begin{cases} 1 - \exp \left\{ - \left[ - \left( \frac{r - \mu}{\psi} \right) \right]^{-\alpha} \right\}, & r < \mu, \psi > 0, \alpha > 0; \\ 1, & r \geq \mu \end{cases} \\ \text{Weibull type : } H(r) &= \begin{cases} 1 - \exp \left[ - \left( \frac{r - \mu}{\psi} \right)^{\alpha} \right], & r > \mu, \psi > 0, \alpha > 0 \\ 0, & r \leq \mu \end{cases} \end{aligned}$$

These three types can be combined into a single GEV family of distributions of the form:

$$H(r) = \begin{cases} 1 - \exp \left\{ - \left[ 1 - \zeta \left( \frac{r - \tau}{\sigma} \right) \right]^{-1/\zeta} \right\}, & 1 - \zeta \left( \frac{r - \tau}{\sigma} \right) > 0, \sigma > 0, \zeta \neq 0 \\ 1 - \exp \left[ - \exp \left( \frac{r - \tau}{\sigma} \right) \right], & \sigma > 0, \zeta = 0 \end{cases},$$

where  $\tau$  is a location parameter indicating where extrema are located on average,  $\sigma$  is a scale parameter indicating the dispersion of extreme realizations, and  $\zeta$  is a shape parameter describing the thickness of extreme distribution tails (Jenkinson, 1955). The case  $\zeta = 0$  corresponds to the Gumbel family, which is thin-tailed;  $\zeta < 0$  corresponds to the Weibull distribution, which is short-tailed;  $\zeta > 0$  corresponds to the Fréchet type, which is a thick (fat)-tailed process.

For sufficiently large  $n$ , it can be easily obtained that:

$$\Pr(R < r) \approx H_{\xi, \tau, \sigma}(r),$$

which can be interpreted as the probability of sample minimum dropping below a specific low level. If we apply this result to investment return, then for any specified large investment loss  $r$  (e.g., a 50% loss),  $\Pr(R < r)$  indicates the chance of losing more than 50% of the investment value. This offers intuitive inference on *extreme* tail risk.

The GEV parameter estimation procedure involves a block extrema sampling. Specifically, for time-series data, the full period can be divided into non-overlapping sub-periods, each representing one block. Per-block minima constitute the extrema sample that follows the GEV distribution asymptotically. The maximum likelihood estimation (MLE) method can be used to estimate the parameters, providing unbiased, asymptotically normal estimates with minimum variances, especially for  $\zeta > -1/2$ .

<sup>27</sup>For sample maximum, since  $\max\{X_1, X_2, \dots, X_n\} = -\min\{-X_1, -X_2, \dots, -X_n\}$ , similar results can be derived.

<sup>28</sup>A non-degenerate distribution does not put all its mass at a single point.

### 3.3. Data and extreme tail risk estimation

When applying the EVT to financial market data, we notice potential dependence and heteroscedasticity of stock returns, which do not respect the i.i.d. assumption. The choice of GEV model is to partially mitigate this problem. Under the block sampling method, independence of the extrema is likely to be a reasonable approximation. In this paper, we use one month as the block window and conduct extrema sampling in daily return observations.<sup>29</sup> We also utilize two more approaches as further remedies. First, we estimate extreme tail risk based on a 60-month rolling window scheme, which can partially capture potential time dependency of GEV parameters and sample variance.<sup>30</sup> Second, we apply the model to market-adjusted return series. Specifically, we compute daily market-adjusted return as the difference between an individual stock's return and the NASDAQ Composite Index return, and fit monthly minima into the GEV distribution to derive extreme tail risk estimate, using the last 60 months of data.<sup>31</sup> By adjusting market return, systemic movements of stock price can be largely factored out. The residual returns are essentially firm-specific and the i.i.d. property can be improved.<sup>32</sup> More importantly, a stock's extreme risk relative to the market makes more economic sense: a 20%-plus daily price drop may not be considered as extreme on the Black Monday of 1987 as in normal times.<sup>33</sup> Abnormal extreme risk relevant to delisting is more idiosyncratic than systematic, fraudulent manipulations normally target at certain stocks rather than the whole market, and marketwide price slumps due to systemic crisis should not involve consequences of delisting: after all, an exchange cannot simply delist a majority amount of listed securities when most issuers are undergoing financial hardships. This might be why the NASDAQ introduced suspensions of the minimum bid price rule during systemic market turmoil periods. Given the long and asymmetric time series involved in this study, factoring out market changes over time and updating information through rolling window scheme can make a clearer inference on extreme risk dynamics caused by the one-dollar rule.<sup>34</sup>

While making efforts to make the GEV fitting more suitable for equity return data, we are also aware that EVT models have only asymptotic justifications and the derived extreme tail risk estimate at best is an approximation and should not be treated as exact result for finite samples. Nevertheless, the basic methodology of this study is to examine unusual price collapses that are reflected in return distribution tails, and as an unique technique to focus on the unusual, EVT produces models that by their nature should provide better description of tail behaviors than traditional mean-centered risk measures. We specifically highlight this point by comparing the GEV-based tail risk measure with

<sup>29</sup>Longin (1996) shows that the shape parameter estimate is not sensitive to the length of sub-period (block). Our results are robust under different block length schemes.

<sup>30</sup>Jondeau and Rockinger (2003) point out that the asymptotic property does not require that realizations of the entire sample be i.i.d. if the subsamples are i.i.d. A  $N$ -history approach can be applied so that this condition is more likely to be satisfied.

<sup>31</sup>A longer period provides more extrema observations for estimation, but less efficiency in reflecting time variations. A 60-month rolling window length is used to find a balance in this trade-off. Other window lengths deliver similar results.

<sup>32</sup>Firm-specific return series can also be obtained through a market model or the Fama and French (1993) three factor model, both of which provide similar results.

<sup>33</sup>On October 19, 1987 (Monday), the Dow Jones Industrial Average index dropped by 22.61%.

<sup>34</sup>This methodology benefits greatly from comments and suggestions from an anonymous referee and the Editor.

other standard risk indicators in Section 4.3. Furthermore, to check robustness of the GEV model, we also conduct similar tail risk estimation from other popular EVT methods based on threshold exceedances. Even though these alternative approaches require different assumptions, they give qualitatively consistent results.<sup>35</sup> Overall, even without limitations, the GEV approach serves to provide informative inference on extreme tail risk.

Based on the above considerations, we conduct data sampling on all NASDAQ-listed common stocks with trading information records in the Center for Research in Security Prices (CRSP) daily data file from 1975 through 2009. We focus on the two periods before and after the introduction of the one-dollar rule, as illustrated in Fig. 1. Since the NASD first proposed the rule to the SEC on April 9, 1990, and the SEC officially approved it on August 30, 1991, we define the period between January 1, 1975 and March 31, 1990 as the pre-rule period, and the period from September 1, 1991 to December 31, 2009 is defined as the post-rule period. The interim between April 1, 1990 and August 31, 1991 is excluded to avoid possible noises due to unclear market reactions to the proposed rule change.

We compute daily stock returns using the average of bid and ask prices, adjusting for distributions (such as dividend payments) and stock splits. This is to mitigate potential microstructure biases due to bid-ask bounces, as demonstrated by Park (1995). For large price declines, which are the focus of this paper, such biases are more severe, especially for low-priced stocks where the bid-ask spread takes a high proportion of price level. Bid-ask bounces also reflect the impact of illiquidity on many low-priced securities, which may make stock returns appear extraordinary despite no significant changes in fundamentals or trading activities. Returns computed using bid-ask averages can help capture large value changes that are free from the bid-ask spread effect.

We calculate market-adjusted returns by deducting the NASDAQ Composite Index return from each stock's return each day, and within the pre- and post-rule periods, we divide full time-series daily data into a sequence of non-overlapping sub-periods, each representing one month. Minimum daily market-adjusted return is identified out of each sub-period to constitute one observation in the extrema sample.<sup>36</sup> MLE is then applied to the extrema sample to estimate parameters in the GEV model on a 60-month rolling window basis. Measure of extreme tail risk is computed according to  $p = \Pr(R < r) \approx H_{\xi, \tau, \sigma}(r)$ , as described in Section 3.2. We use 50% loss to represent the specified large value drop level.<sup>37</sup> Therefore, the resulting extreme tail risk can be interpreted as the probability of larger than 50% loss in excess of market for the worst return day in any particular month, or losing more than half of investment value in one day is expected to happen once every  $1/p$  months on average.

### 3.4. Descriptive statistics

For a large number of NASDAQ-listed companies, reaching the \$1 bottom line is not a remote possibility as usually perceived despite the seemingly low level of the threshold. According to the descriptive statistics in Table 1, during both the pre- and post-rule

<sup>35</sup>Specifically, we estimate extreme tail risk derived from the generalized Pareto distribution (GPD) approach and a model based on the Hill estimator. Detailed technical notes and estimation results are available from the authors upon request.

<sup>36</sup>We exclude from the sample the minima of the first and last partial months and the months that have less than 10 daily return observations.

<sup>37</sup>Using other large loss levels provides similar evidence as reported in the paper.

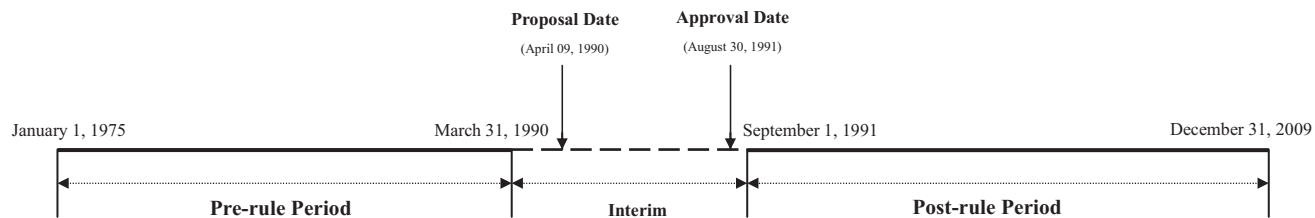


Fig. 1. Sample period construction. The NASD first proposed the NASDAQ \$1 minimum bid price listing standard (the one-dollar rule) to the SEC on April 9, 1990, and the SEC officially approved it on August 30, 1991. The period between January 1, 1975 and March 31, 1990 is defined as “Pre-rule Period” and the period between September 1, 1991 and December 31, 2009 is defined as “Post-rule Period.” The interim between April 1, 1990 and August 31, 1991 is excluded.

Table 1

Descriptive statistics of “breaking \$1” stocks on the NASDAQ.

This table reports the number and percentage of stocks experiencing a closing bid price less than \$1 (“breaking \$1”) during a specific period. The sample includes all NASDAQ-listed common stocks from January 1975 to December 2009. The statistics are reported for two periods before and after implementation of the \$1 minimum bid price continued listing requirement (the one-dollar rule). The NASD first proposed the rule to the SEC on April 9, 1990, and the SEC officially approved it on August 30, 1991. The period between January 1, 1975 and March 31, 1990 is defined as “Pre-rule period” and the period between September 1, 1991 and December 31, 2009 is defined as “Post-rule period.” The interim between April 1, 1990 and August 31, 1991 is excluded.

Period	Number of All Stocks	Number of Stocks “Breaking \$1”	%
Pre-rule period (01/01/75-03/31/90)	9009	3347	37.15
Post-rule period (09/01/91-12/31/09)	10723	4473	41.71

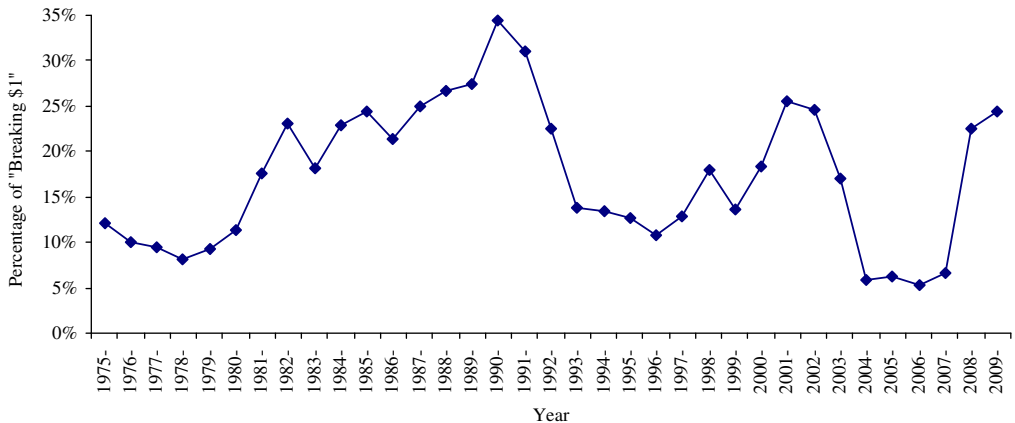


Fig. 2. Percentage of stocks “breaking \$1” on the NASDAQ. This figure depicts the percentage of stocks experiencing a closing bid price less than \$1 (“breaking \$1”) for each year between 1975 and 2009.

periods, more than one-third of NASDAQ stocks experience a closing bid price below \$1. As shown in Fig. 2, the percentage of stocks breaking the \$1 floor exhibits an upward trend and peaks in 1990 with a level of 34% when the one-dollar rule is proposed.<sup>38</sup> This trend stops in 1991 when the rule is enacted, and the “breaking \$1” rate sharply declines afterwards and drops below 11% in six years. During the dotcom crash and 2008–2009 market meltdown periods, the rate increases again, reaching a level higher than 24%.

An examination of delisting rates provides a clearer picture of the impact of the one-dollar rule. Table 2 presents delisting statistics after implementation of the NASDAQ minimum bid price standard. Panel A reports numbers and percentages of delistings due to failures of meeting different listing requirements. In addition to the \$1 bid price threshold,

<sup>38</sup>It is understandable that the “breaking \$1” rates in Table 1 are larger than the rates in Fig. 2. According to the computing method, the longer the sample period, the higher the possibility of having a history with a price below \$1.

Table 2

NASDAQ delistings statistics after implementation of the one-dollar rule.

This table reports summary statistics of delistings on the NASDAQ after implementation of the \$1 minimum bid price continued listing requirement (the one-dollar rule). Panel A reports numbers and percentages of delistings due to various forms of non-compliance. Panel B reports the number and percentage of delistings due to not being able to maintain a bid price greater than \$1. The statistics are computed each year between 1992 and 2009.

Panel A: All Types of Delistings			
CRSP Delisting Code	Description	Number of Delistings	%
550	Insufficient number of market makers	48	2.61
551	Insufficient number of shareholders	34	1.85
552	Price fell below acceptable level	767	41.78
560	Insufficient capital, surplus, and/or equity	437	23.80
561	Insufficient (or non-compliance with rules of) float or asset	537	29.25
587	Corporate governance violation	13	0.71
Panel B: Delistings Due to Minimum Bid Price Non-compliance			
Year	Total Number of Delistings	Number of Delistings Due to Minimum Bid Price Non-compliance	%
1992	252	59	23.41
1993	88	21	23.86
1994	94	40	42.55
1995	113	43	38.05
1996	91	29	31.87
1997	122	38	31.15
1998	200	63	31.50
1999	224	98	43.75
2000	135	58	42.96
2001	185	144	77.84
2002	103	71	68.93
2003	68	41	60.29
2004	17	1	5.88
2005	33	15	45.45
2006	17	10	58.82
2007	2	0	0.00
2008	44	19	43.18
2009	48	17	35.42

the NASDAQ sets minimum levels for other financial indicators such as total assets or equity, number of market makers or shareholders, and corporate governance standard (see [Appendix A](#)). Among all of these criteria, the minimum bid price rule is the most influential one, leading to 767 NASDAQ delistings (or 41.78% of total delistings) after 1991, followed by total assets (29.25%) and total equity requirements (23.80%), which are also closely related to stock price. In contrast to these criteria, the impact of number of market makers, number of shareholders, and corporate governance requirements is trivial, together accounting for only about 5% of all delistings.

The influence of the one-dollar rule is further evidenced in Panel B of Table 2, where annual number and percentage of delistings due to minimum bid price non-compliance are reported. The delisting rates caused by violating the one-dollar rule are surprisingly large during most of the study periods, especially in the early 2000s. Despite NASDAQ's emergency moratorium, which suspends the minimum bid price standard for more than three months in 2001, the delisting rate remains high at 77.84% in that year. Although the total number of delistings drops sharply after the NASDAQ bubble burst, violation of the minimum bid price rule still accounts for the lion's share in most years.

#### 4. Cross-stock and inter-period variations of extreme tail risk and standard risk indicators

We categorize stocks according to their bid prices in order to examine the extreme tail risk of individual stocks at different price levels. For the purpose of evaluating the one-dollar rule, the natural cutoff price is \$1. However, a particular stock may not be easily designated into low- or high-priced categories relative to \$1 because its bid price may move up and down around \$1. To circumvent this problem, we label securities with closing bids (or closing prices if bids are not available) falling below \$1 for at least half of all trading days in either the pre- or post-rule period as “under \$1” stocks (i.e., stocks with median (bid) prices  $MP \leq \$1$ ), which are more likely to break \$1.<sup>39</sup> Other stocks are sorted into control groups to be contrasted with “under \$1” stocks. Extreme tail risk comparisons are conducted among different portfolios or across different periods.

##### 4.1. Extreme tail risk in the pre-rule period

We believe that extremely low-priced stocks are characterized by frequent price collapses, which are detrimental to investors' interests and an exchange's reputation. In the EVT approach, this implies that the extreme tail risk of low-priced stocks is abnormally higher than that of relatively high-priced stocks. The pre-rule period provides a suitable environment for such a test. Because there is no minimum bid price rule during this period, extreme tail risk characteristics of low- and high-priced (relative to \$1) stocks are readily contrasted.

An important aspect of the minimum bid price rule is that as long as price falls below the benchmark level for a certain period (e.g., 30 consecutive business days under NASDAQ's current policy), the stock will face delisting (after a grace period), regardless of any other financial conditions of the issuer. In this sense, application of the one-dollar rule is unconditional. It concentrates exclusively on bid price. To be consistent with this feature, we focus on bid price level and construct two price-based portfolios: Portfolio 1 of stocks “under \$1” and Portfolio 2 of stocks “above \$1” ( $MP > \$1$ ) in the control group.

We conduct per-month minima sampling of market-adjusted returns in the two periods for each stock of the two portfolios, and compute GEV-based probability of extreme loss using the last 60 months of observations. This procedure updates extreme tail risk estimates every month.<sup>40</sup> A time-series exhibition of monthly average extreme tail risk estimates for the two portfolios in the pre-rule period is seen on the left half of Fig. 3.

<sup>39</sup>We also conduct robustness checks by using critical percentile points other than the median price to divide stocks into different groups and reach similar conclusions.

<sup>40</sup>Based on the 60-month rolling window scheme, valid extreme tail risk estimates start from December 1979 for the pre-rule period and from August 1996 for the post-rule period.

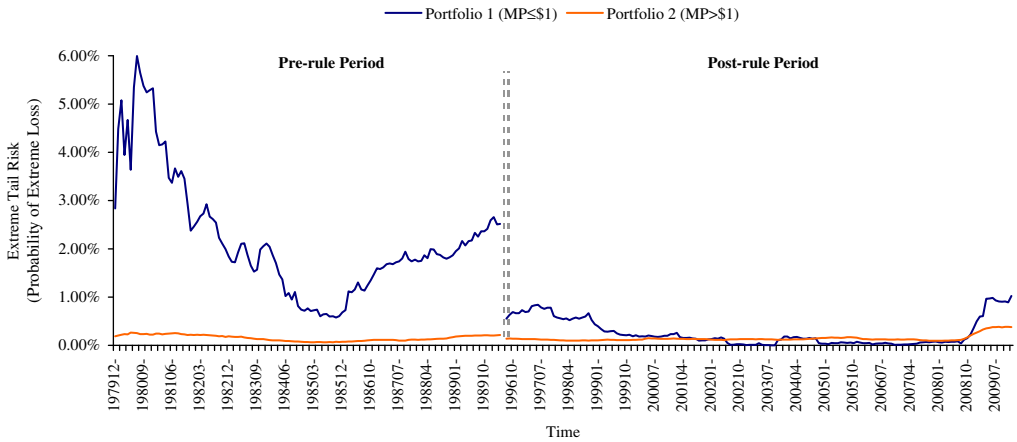


Fig. 3. Time-series of extreme tail risk. This figure depicts time-series levels of GEV-based extreme tail risk for two price-based portfolios in two periods. Extreme tail risk is estimated using daily market-adjusted returns on a 60-month rolling window basis, after controlling for bid-ask bounces. “Pre-rule Period” and “Post-rule Period” refer to the periods before and after implementation of the NASDAQ \$1 minimum bid price continued listing requirement (the one-dollar rule), respectively. “Portfolio1” and “Portfolio 2” contain stocks with median daily closing bid prices (MP) below and above \$1 in each period, respectively.

A dramatic difference is observed in the estimated extreme tail risk for the two portfolios throughout the entire pre-rule period. The extreme loss probability of stocks “under \$1” (Portfolio 1) is substantially higher than that of stocks in the control group (Portfolio 2). We also observe a large time-series variation of extreme tail risk for “under \$1” stocks: there is a peak in early 1980s and then a decline until mid-1980s. After 1985, extreme tail risk increases again, and the trend doesn’t stop until the introduction of the one-dollar rule. The highest extreme tail risk appears in July 1980 with a level of 6%. This means that, on average, there is a 6% chance that a stock loses more than half of its value (relative to the market) on the minimum return day in any particular month. In other words, losing more than half of investment value in one day, which normally is perceived as rare as an once in a century event, is expected to happen once every  $16.67 [= 1/(6\%)]$  months, which is less than 1.5 years. For about 44% of the pre-rule period, extreme loss probability is higher than 2% for stocks frequently trading below \$1. As a sharp contrast, extreme tail risk of stocks in Portfolio 2 is substantially lower in magnitude and relatively stable over time. During the whole pre-rule period, extreme loss probability for “above \$1” stocks never exceeds 0.27%, and the minimum is 0.065% (February 1985), which makes losing more than 50% value in one day a once in  $128 \{=[1/(0.065\%)]/12\}$  years event.

For a more accurate quantitative description, we report time-series average extreme tail risk for each group in Panel A of Table 3 under the “Pre-rule Period” column. Since the table also reports inter-period percentage changes of extreme tail risk that will be analyzed later, we show extreme tail risk in “basis point” instead of percentage to avoid possible confusions—100 basis points represent a 1% probability of extreme loss.

For stocks “under \$1” in Portfolio 1, average extreme loss probability is 221 basis points (2.21%), whereas that of Portfolio 2 is 15 basis points (0.15%). Average extreme tail risk associated with more likely to break \$1 group is more than 14 times larger than that of

Table 3

Comparisons of average extreme tail risk and other standard risk indicators.

GEV-based extreme tail risk and standard risk indicators (standard deviation, skewness, kurtosis) are estimated using daily market-adjusted returns on a 60-month rolling window basis, after controlling for bid-ask bounces. Panels A to D report time-series averages of these four risk estimates for two price-based portfolios in two periods before and after implementation of the NASDAQ \$1 minimum bid price continued listing requirement (the one-dollar rule). The period between January 1, 1975 and March 31, 1990 is defined as “Pre-rule Period” and the period from September 1, 1991 to December 31, 2009 is defined as “Post-rule Period.” “Portfolio 1” includes stocks with closing bid prices falling below \$1 for at least half of all trading days, i.e., with median closing bid prices (MP) less than or equal to \$1. All other stocks are assigned into “Portfolio 2.”

Panel A: Extreme Tail Risk (Probability of Extreme Loss in “Basis Point”)

Portfolio	Period		Post-Pre	Percentage Change
	Pre-rule Period	Post-rule Period		
Portfolio 1 (MP ≤ \$1)	221	26	−195 <sup>***</sup>	−88.24%
Portfolio 2 (MP > \$1)	15	14	−1	−6.67%

Panel B: Standard Deviation

Portfolio	Period		Post-Pre	Percentage Change
	Pre-rule Period	Post-rule Period		
Portfolio 1 (MP ≤ \$1)	0.05	0.07	0.02 <sup>***</sup>	40.00%
Portfolio 2 (MP > \$1)	0.02	0.04	0.02 <sup>***</sup>	100.00%

Panel C: Skewness

Portfolio	Period		Post-Pre	Percentage Change
	Pre-rule Period	Post-rule Period		
Portfolio 1 (MP ≤ \$1)	2.68	3.20	0.52 <sup>***</sup>	19.40%
Portfolio 2 (MP > \$1)	1.49	1.35	−0.14 <sup>***</sup>	−9.40%

Panel D: Kurtosis

Portfolio	Period		Post-Pre	Percentage Change
	Pre-rule Period	Post-rule Period		
Portfolio 1 (MP ≤ \$1)	42.57	45.25	2.68	6.30%
Portfolio 2 (MP > \$1)	27.06	28.30	1.24 <sup>**</sup>	4.58%

\*\*\*denotes significance at the 1% level.

\*\*denotes significance at the 5% level.

control group. The extraordinarily higher extreme tail risk of “under \$1” stocks in the pre-rule period indicates that, before implementation of the minimum bid price rule, low-priced (relative to \$1) securities on the NASDAQ do suffer substantially from extreme price plunges. The frequency and severity of steep price drops are far beyond those associated with “above \$1” securities. Such an extreme tail risk anomaly of stocks frequently breaking \$1 is severe enough to deserve serious attention from both regulators and investors, and setting a minimum price maintenance criterion is a convenient way to screen NASDAQ listings and uphold the exchange’s reputation.

#### 4.2. Extreme tail risk after implementation of the one-dollar rule

A natural question is whether the one-dollar rule works to reduce detrimental extreme risk for stocks listed on the NASDAQ. An examination of extreme tail risk in the post-rule period will serve to assess the efficacy of the rule. Fig. 3 and Pane A of Table 3 show the results.

Contrasting across two periods for stocks “under \$1” reveals a striking finding: the extreme tail risk of low-priced (relative to \$1) stocks becomes substantially lower after adoption of the minimum bid price standard. From Fig. 3, we observe an obvious downward jump of extreme tail risk after implementation of the one-dollar rule. Before the crash of 2008–2009, the probability of extreme loss never exceeds 0.90% and keeps below 0.20% after March 2003. On the contrary, extreme loss probability for “above \$1” stocks does not exhibit large inter-period change, and is stable between 0.10% and 0.20% until the recent market turmoil. For more than 42% of the entire post-rule period, extreme tail risk of “under \$1” stocks is *lower* than that of high-priced (relative to \$1) stocks. This is a sharp contrast to the picture of cross-portfolio extreme risk difference before the one-dollar rule.

Panel A of Table 3 reports time-series average extreme tail risk estimates for the two portfolios in two periods. For low-priced (relative to \$1) stocks in Portfolio 1, average extreme tail risk declines from a high level of 221 basis points in the pre-rule period to a low of 26 basis points in the post-rule period, exhibiting a significant 88.24% inter-period decrease. For “above \$1” stocks in Portfolio 2, average extreme tail risk only decreases by 1 basis point from the pre- to the post-rule period and the change is neither economically nor statistically significant.

The post-rule period specified above also includes the moratorium times when the one-dollar rule was suspended by the NASDAQ. As mentioned in Section 2 and Appendix B, responding to marketwide price turbulences, the NASDAQ applied two temporary suspensions of its continued listing requirement relating to bid price during 09/2001–12/2001 and 10/2008–07/2009, respectively. It is of interest to check the extreme risk characteristics for “under \$1” stocks during these rule-free periods: a significant increase or jump of extreme tail risk can further confirm the effects of the one-dollar rule. We present results of this natural experiment in Fig. 4, which is an enlarged picture of the post-rule period part of Fig. 3. The shaded areas represent suspension periods. For low-priced (relative to \$1) stocks, extreme tail risk does show obvious increases upon rule suspensions. Before the 2001 suspension, extreme tail risk is in a declining trend. The risk level becomes as low as less than 10 basis points in September 2001. With the suspension initiated, extreme tail risk starts to rise, and reaches over 12 basis points in December 2001, exhibiting a 20%-plus increase in three months. More substantial increase is observed in the 2008–2009 suspension time. The probability of extreme loss for “under \$1” stocks jumps from below 15 basis points at the beginning of the moratorium to over 93 basis points by the end of the suspension period. This is an increase over six times within 10 months. In contrast, extreme tail risk for “above \$1” stocks does not exhibit an increase in the 2001 suspension time. During the 2008–2009 suspension period, even though extreme loss probability also shows a large increase (from 16 basis points in October 2008 to 38 basis points in July 2009), the magnitude is much smaller than that of low-priced (relative to \$1) stocks. Moreover, further scrutiny reveals that the increase is largely driven by stocks whose prices drop below \$1 under the turbulent market conditions. Excluding

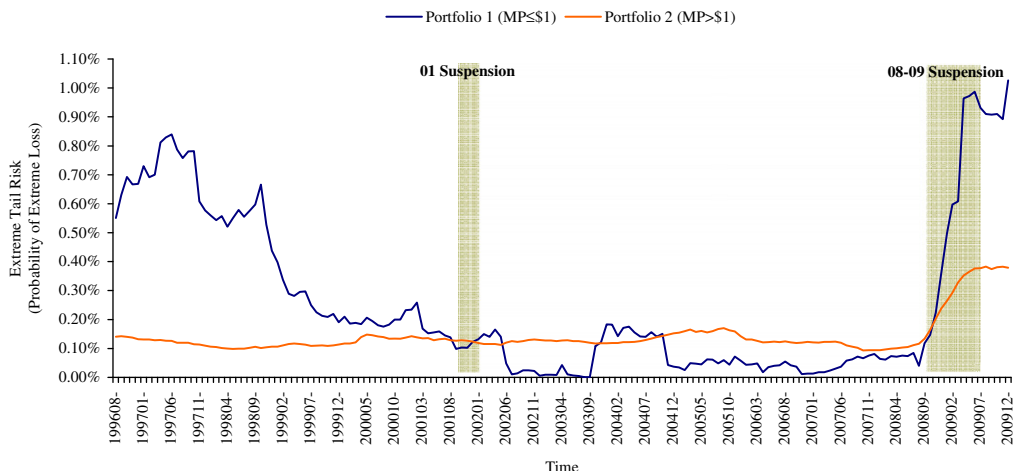


Fig. 4. Extreme tail risk during the one-dollar rule suspension periods. This figure depicts time-series levels of GEV-based extreme tail risk for two price-based portfolios after implementation of the NASDAQ \$1 minimum bid price continued listing requirement (the one-dollar rule). Extreme tail risk is estimated using daily market-adjusted returns on a 60-month rolling window basis, after controlling for bid-ask bounces. “Portfolio 1” and “Portfolio 2” contain stocks with median daily closing bid prices (MP) below and above \$1, respectively. The shaded areas indicate the two periods (09/2001–12/2001 and 10/2008–07/2009) when the NASDAQ temporarily suspended the one-dollar rule.

those stocks reduces the average extreme tail risk of July 2009 to a low level of 22 basis points.

In general, the extreme tail risk of low-priced (relative to \$1) stocks largely diminishes after the one-dollar rule is applied. If the rule is suspended, extreme tail risk shows an immediate increase or jump. One potential explanation for this observation may be the implementation of the minimum bid price rule among the many efforts to upgrade list standards on the NASDAQ, which delists “problematic” securities and improves the atmosphere of the exchange. In this sense, the minimum bid price criterion has proved effective.

#### 4.3. Inter-period variations of standard risk indicators

Theoretically, EVT models provide specific tools for describing tail behaviors, and the GEV-based measure is a more reliable proxy for extreme risk than other traditional mean-centered risk indicators. In this section, we examine inter-period changes of standard risk measures to demonstrate the uniqueness of extreme tail risk in detecting price collapses. If no standard risk indicator reflects the dynamics of abnormal price drops as well as the GEV-based risk measure, the statistical foundation of using the EVT approach to evaluate the minimum bid price rule is further strengthened.

We utilize the same market-adjusted daily returns to estimate standard risk indicators after controlling for bid-ask bounces, to be consistent with the estimation of extreme tail risk. For the two price-based portfolios, we compute three representative risk measures in the pre- and post-rule periods, also on a 60-month rolling window basis: standard deviation, skewness, and kurtosis. Standard deviation is a traditional volatility measure;

skewness and kurtosis are high moment indicators and describe deviations from the normal distribution. All these measures are known to play important roles in reflecting distribution characteristics. The corresponding time-series average statistics are reported in Panels B to D of Table 3.

Similar to extreme tail risk, standard deviation, skewness, and kurtosis for stocks in Portfolio 1 are much higher than those for stocks in Portfolio 2. This implies that firm-specific returns are more volatile, more positively skewed, and have fatter distribution tails for “under \$1” securities. However, these standard risk measures exhibit completely different inter-period dynamics in most cases, especially for stocks in Portfolio 1. We have documented extraordinary extreme tail risk estimates for stocks “under \$1” in the pre-rule period and sharp risk reductions after implementation of the one-dollar rule. No such change is observed for standard risk indicators. Standard deviation and skewness *increase* significantly for more likely to break \$1 stocks from the pre- to the post-rule period, with percentage changes of 40.00% and 19.40%, respectively. There is also an inter-period increase of kurtosis, even though the change is not statistically significant. Interestingly, the two high moment indicators (skewness and kurtosis) of low-priced (relative to \$1) stocks do not share the same time-series dynamics with the GEV-based risk measure, even though they also contain some information about tail behaviors of return distribution. After all, the third (skewness) and fourth (kurtosis) moments, like the second moment (standard deviation), are essentially mean-centered measures and the information they convey about tail risk is likely to be much noisier than that signaled by EVT models.

## 5. Extreme tail risk of penny stocks, falling angels, and other stocks of different price levels

Among “under \$1” securities that are flushed by the one-dollar rule, some may have always been penny stocks while some may be fallen angels that have experienced dramatic price decreases from a high level to below \$1. Since high-priced (relative to \$1) securities have substantially lower extreme tail risk than those “under \$1”, the always-penny stocks should exhibit large extreme loss probability, and the fallen angels should enjoy lower probability of extreme loss when their prices are high and suffer from elevated extreme tail risk after falling below \$1. As a robustness check, we specifically examine extreme tail risk of penny stocks and fallen angels by treating them as subgroups of “under \$1” securities.<sup>41</sup> We follow SEC’s guidance to define penny stocks as those whose bid prices never exceed \$5. Fallen angels refer to stocks that have previously traded at \$10 or more and then fallen below \$1. Other low-priced (relative to \$1) issues are designated to a third group called ordinary “under \$1” stocks. We report time-series average extreme tail risk statistics for these subgroups in the upper part of Table 4.

Before the rule change, among the three subgroups, penny stocks exhibit the highest average extreme loss probability of 256 basis points while fallen angels show the lowest; the former is almost two times the latter. This indicates that the more deeply into \$1, the higher the extreme tail risk. The dampened extreme tail risk of fallen angels is actually caused by low risk when price is high. Further analysis reveals that average extreme loss probability of fallen angels is only 38 basis points before they fall below \$1. Extreme tail

<sup>41</sup>We thank an anonymous referee for suggesting this analysis.

Table 4

Average extreme tail risk of different price-based portfolios.

This table reports time-series average GEV-based extreme tail risk estimates (in basis point) for three portfolios of “under \$1” stocks (rows 1–3), and nine portfolios of “above \$1” stocks (rows 4–12). “Pre-rule Period” and “Post-rule Period” refer to the periods before and after implementation of the NASDAQ \$1 minimum bid price continued listing requirement (the one-dollar rule), respectively. “Penny stocks” portfolio includes “under \$1” stocks that always trade at \$5 or below; “Fallen angels” are defined as “under \$1” stocks that have previously traded at \$10 or above and then fallen below \$1; “Ordinary ‘under \$1’ stocks” are neither penny stocks nor fallen angels. MP(1,2] through MP(20,∞) refer to portfolios of stocks with median daily closing bid prices falling into a certain range in each period. MP(1,2] contains stocks with median daily closing bid prices between \$1 and \$2, and so on. The last portfolio MP(20,∞) consists of stocks with median daily closing bid prices higher than \$20.

Portfolio	Period		Post-Pre	Percentage Change
	Pre-rule Period	Post-rule Period		
“Under \$1” stocks				
1, Penny stocks	256	26	−230 <sup>***</sup>	−89.84%
2, Ordinary “under \$1” stocks	144	31	−113 <sup>***</sup>	−78.47%
3, Fallen angels	129	14	−115 <sup>***</sup>	−89.15%
“Above \$1” stocks				
4, MP(1, 2]	64	24	−40 <sup>***</sup>	−62.50%
5, MP(2, 3]	64	22	−42 <sup>***</sup>	−65.63%
6, MP(3, 4]	37	20	−17 <sup>***</sup>	−45.95%
7, MP(4, 5]	21	17	−4 <sup>***</sup>	−19.05%
8, MP(5, 7.5]	12	17	5 <sup>***</sup>	41.67%
9, MP(7.5, 10]	6	17	11 <sup>***</sup>	183.33%
10, MP(10, 15]	6	12	6 <sup>***</sup>	100.00%
11, MP(15, 20]	3	10	7 <sup>***</sup>	233.33%
12, MP(20, ∞)	2	7	5 <sup>***</sup>	250.00%

\*\*\*denotes significance at the 1% level.

risk climbs to a high level of 256 basis points after the falling, which is of the same magnitude for penny stocks. Such a big jump confirms our general conclusion that trading below \$1 is associated with extraordinarily high probability of extreme loss prior to the one-dollar rule. For fallen angels, even though average extreme tail risk is lower than that of penny stocks, after their falling, dramatically increased risk keeps the overall extreme loss probability at a substantially high level of 129 basis points (still much higher than the 15 basis points for “above \$1” stocks in Table 3 Panel A). One more observation is that extreme loss probabilities of these three subgroups all become much smaller in the post-rule period. This is very similar to the result for “under \$1” stocks in Panel A of Table 3. Therefore, evidence here provides consistent supports for the basic conclusion from Section 4, and reinforces the fact that price dropping below \$1 entails large extreme tail risk.

Following the same spirit, we also conduct detailed subsample analyses for “above \$1” stocks. This can help in detecting a more accurate relation between share price and extreme tail risk, and more importantly, can provide inference on the specific cutoff level of \$1 in the minimum bid price rule. If there is a substantially large difference in extreme loss probability between stocks frequently trading below and above \$1, one dollar can be

considered a good watershed since it can distinguish abnormally high extreme tail risk stocks from more “normally” behaved ones.

Among “above \$1” stocks, we construct portfolios according to the percentage of time daily closing bid prices fall into a certain range, where median is taken as the critical percentile point to be consistent with previous analyses. In each of the two periods, we divide the full sample by eight watershed median price levels: \$2, \$3, \$4, \$5, \$7.5, \$10, \$15, and \$20. Stocks are correspondingly assigned into nine price-based portfolios as listed in the lower part of Table 4, where MP(1, 2] contains stocks with median closing bids between \$1 and \$2, and so on. The last portfolio MP(20,  $\infty$ ) consists of stocks with median closing bids greater than \$20.

There is a pattern that lower price is generally accompanied by higher extreme tail risk, especially in the pre-rule period when risk gaps between different price-based portfolios are relatively larger than those in the post-rule period. This evidence is in support of the argument that share price does convey important information about extreme tail risk. Another observation can be obtained by comparing extreme tail risk between “under \$1” and “above \$1” portfolios. In the pre-rule period, extreme loss probability of “under \$1”

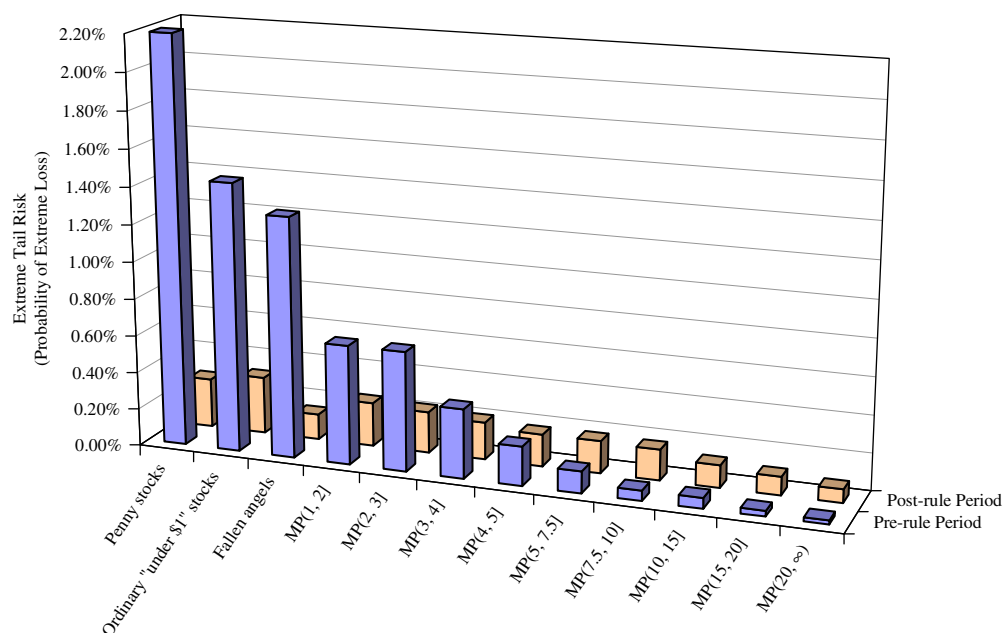


Fig. 5. Average extreme tail risk of price-based portfolios in two periods. This figure depicts time-series average extreme tail risk levels for 12 price-based portfolios in two periods. Vertical line represents GEV-based extreme loss probability. “Pre-rule Period” and “Post-rule Period” refer to the periods before and after implementation of the NASDAQ \$1 minimum bid price continued listing requirement (the one-dollar rule), respectively. “Penny stocks” portfolio includes “under \$1” stocks that always trade at \$5 or below; “Fallen angels” are defined as “under \$1” stocks that have previously traded at \$10 or above and then fallen below \$1; “Ordinary ‘under \$1’ stocks” are neither penny stocks nor fallen angels. MP(1,2] through MP(20,  $\infty$ ) refer to portfolios containing stocks with median daily closing bid prices (MP) falling into a certain range within each period. The two numbers in each portfolio name represent the lower and upper boundaries of the price range.

stocks is substantially greater than that of stocks in any of the “above \$1” portfolios. Consistent with previous findings, inter-period changes in extreme tail risk are far less dramatic for stocks in “above \$1” subgroups than those “under \$1.” Extreme tail risk even *increases* significantly for stocks priced higher than \$5 after the one-dollar rule. Therefore, the minimum bid price rule entails more substantial reductions in extreme loss probability for stocks frequently trading below \$1 than above \$1. Fig. 5 depicts extreme tail risk estimate for each portfolio in each period. It can be easily observed that the \$1 benchmark plays a significant role in differentiating stocks of high and low extreme tail risk and in reducing extreme loss probability for low-priced (relative to \$1) stocks. This evidence upholds policy makers’ perception of \$1 as a suitable level for the discriminatory price variable to regulate exchange listing maintenance.

## 6. Conclusion

On major U.S. stock exchanges, especially the NASDAQ, delisting a listed company is not uncommon for the reason that its stock price falls below a \$1 minimum threshold. This paper empirically evaluates this listing maintenance requirement (the one-dollar rule). We argue that stocks breaking the \$1 floor are usually characterized by dramatic price collapses that may be devastating to investors’ interests and detrimental to the exchange’s integrity. We use an extreme loss probability measure under extreme value approach to demonstrate that catastrophic price drops relative to the market are generally associated with stocks frequently trading below \$1. We document sharp declines in extreme tail risk after the one-dollar rule is imposed. The \$1 threshold proves appropriate because it can distinguish stocks with abnormally high extreme tail risk from their counterparts. Overall, share price acts as a good discriminatory variable for regulatory purposes, and this study provides evidence in support of NASDAQ’s \$1 minimum bid price continued listing criterion.

The use of pre-determined price as a regulatory vehicle has its merits. Nevertheless, the lessons from the HKEx episode remind market regulators not to have a myopic view on the price rule per se. This paper highlights the importance of treating the minimum price maintenance rule as one part of the comprehensive reforms aiming at upgrading exchange-listed issuer quality and improving low-priced OTC security trading. The PSRA makes OTC markets more regulated. The OTCBB and OTC Markets Group constitute a soft landing mechanism for delisted stocks. On the NASDAQ, while the one-dollar rule is applied, regulators also offer great flexibilities to affected issuers in restoring their compliance with the standard. This is reflected by practices of modifying the length of grace period and temporarily suspending the rule, especially in the past decade. The grace period modification and rule suspension are essentially based on the overall market conditions over time and have become indispensable parts of the minimum price regulation. Managing the grace period and rule suspension, however, is more of an art than a science.

## Appendix A. Continued listing requirements on the NASDAQ

Table A1 presents NASDAQ’s continued listing requirements as of January 2011.

Table A1

NASDAQ's continued listing requirements (January 2011).

The NASDAQ separated its markets into the National Market and the SmallCap Market in August 1991. In September 2005, the SmallCap Market was renamed as the Capital Market, and in July 2006, the NASDAQ created the Global Select Market and renamed the National Market as the Global Market. Equities listed on the Global Select Market and the Global Market are subject to the same maintenance criteria, which are shown in Panel A. Panel B presents maintenance criteria for Capital Market issuers. For detailed information about NASDAQ listing standards, refer to [www.nasdaq.com](http://www.nasdaq.com).

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Panel A: Global Select Market and Global Market

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Requirements	Equity Standard	Market Value Standard	Total Assets/Total Revenue Standard
Stockholders' equity	\$10 million	N/A	N/A
Market value of listed securities	N/A	\$50 million	N/A
Total assets and total revenue	N/A	N/A	\$50 million and \$50 million
Publicly held shares	750,000	1.1 million	1.1 million
Market value of publicly held shares	\$5 million	\$15 million	\$15 million
Bid price	\$1	\$1	\$1
Shareholders (round lot holders)	400	400	400
Market makers	2	4	4
Corporate governance	Yes	Yes	Yes

Panel B: Capital Market

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Requirements	Equity Standard	Market Value of Listed Securities Standard	Net Income Standard
Stockholders' equity	\$2.5 million	N/A	N/A
Market value of listed securities	N/A	\$35 million	N/A
Net income from continuing operations	N/A	N/A	\$500,000
Publicly held shares	500,000	500,000	500,000
Market value of publicly held shares	\$1 million	\$1 million	\$1 million
Bid price	\$1	\$1	\$1
Shareholders (round lot holders)	300	300	300
Market makers	2	2	2
Corporate governance	Yes	Yes	Yes

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## Appendix B. Evolution of U.S. OTC markets for low-priced securities and minimum price continued listing standards

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October 1913

The National Quotation Bureau (NQB) was organized as a quotation service for Over-the-Counter (OTC) market makers (NQB changed its name to Pink Sheets LLC in June 2000, Pink Sheets LLC changed its name to Pink OTC Markets, Inc. in April 2008, and Pink OTC Markets, Inc. changed its name to OTC Markets Group, Inc. in January 2011).

February 8, 1971	The National Association of Securities Dealers Automated Quotation system (NASDAQ) (currently known as the NASDAQ Stock Market operated by the NASDAQ OMX Group, Inc.) began trading.
April 1982	The NASDAQ introduced the National Market System (NMS), predecessor of the NASDAQ National Market (NNM).
May 1988	Schedule H of the National Association of Securities Dealers (NASD) (predecessor of the Financial Industry Regulatory Authority (FINRA)) Bylaws was adopted, which requires dealers in non-NASDAQ securities to report daily transaction volume to the NASD.
January 1, 1990	The Securities and Exchange Commission (SEC) adopted sales practice requirements for certain low-priced, non-NASDAQ securities (Rule 15c2-6 under the Security Exchange Act of 1934).
January 10, 1990	The SEC wrote to the NASD urging it to carefully scrutinize listing standards to ensure that low-priced securities fully complied with all applicable standards.
April 9, 1990	The NASD proposed to the SEC to revise the criteria for initial and continued inclusion of securities in the NASDAQ system, introducing for the first time the minimum bid price standards, applicable to all U.S. and Canadian issuers. For continued listing, the minimum bid price was set at \$1. <sup>a</sup>
June 1, 1990	As part of the market structure reforms to provide transparency on OTC equity markets, the OTC Bulletin Board (OTCBB) began operation as a pilot program.
October 15, 1990	President George H.W. Bush signed the Securities Enforcement Remedies and Penny Stock Reform Act of 1990 (PSRA) into law. Provisions of the PSRA do not apply to any security listing on the NASDAQ.
August 1991	The NASDAQ officially separated its markets into two sectors: the National Market and the SmallCap Market.
August 30, 1991	The SEC officially approved NASD's proposal of revising NASDAQ's initial and continued listing criteria, and the minimum bid price listing standards came into effect. The continued listing rules allowed for a perpetual exemption from the \$1 bid price minimum if the issuer met heightened requirements for the market value of its public float and for the amount of capital and surplus.
April 1997	The NASDAQ eliminated the exemption of \$1 minimum bid price continued listing requirement, and universally applied the standard to all U.S. and Canadian issuers; The SEC approved operation of the OTCBB on a permanent basis.
January 4, 1999	The SEC approved the OTCBB Eligibility Rule which requires securities quoted on the OTCBB to report their current financial information to the SEC.

September 1999	The NQB introduced the Electrical Quotation Service for OTC equities and bonds.
April 2000	The New York Stock Exchange (NYSE) (operated by the NYSE Euronext, Inc.) implemented the \$1 minimum price continued listing standard. <sup>b</sup>
September 27, 2001	The NASDAQ initiated an emergency moratorium and temporarily suspended the application of the continued inclusion bid price requirement.
January 3, 2002	The NASDAQ reinstated the minimum bid price continued listing requirement and introduced a pilot program that contained several amendments to extend the grace period for bid price non-compliance.
January 1, 2005	The NASDAQ ended the pilot program and reduced the maximum two-year grace period for SmallCap issuers in the pilot program to 360 calendar days.
May 29, 2006	The NASDAQ implemented the \$1 minimum bid price continued listing requirement on all non-Canadian foreign issuers listed on the Capital Market.
October 16, 2008	The NASDAQ implemented a temporary suspension of the enforcement of the \$1 minimum bid price requirement for continued listing. This suspension was extended on December 19, 2008, March 18, 2009, and July 14, 2009, and remained in effect through July 31, 2009.
February 29, 2009	The NYSE temporarily suspended the \$1 minimum average closing price requirement for continued listing. This suspension was extended on July 2, 2009, and remained in effect through July 31, 2009.
August 3, 2009	The NASDAQ reinstated the \$1 minimum bid price continued listing requirement; The NYSE reinstated the \$1 minimum average closing price requirement for continued listing.
September 2009	The FINRA proposed to divest itself of the ownership and operation of the OTCBB; The FINRA also proposed to act as the consolidator and disseminator of all quotation and trade information for unlisted equity securities, which invoked disagreements from the OTC Markets Group. <sup>c</sup>

<sup>a</sup>For certain NNM issuers, there was a maintenance Standard 2 which required a \$3 minimum bid price. In March 2003, the \$3 benchmark was replaced by \$1. At that time, there were only about 40 issuers subject to the \$3 requirement.

<sup>b</sup>On the NYSE, a company will be considered to be below compliance standards if the average closing price of a security is less than \$1 over a consecutive 30-trading-day period.

<sup>c</sup>FINRA, 2009, “Over-the-Counter Bulletin Board (OTCBB) sale announcement,” from [www.finra.org/Industry/Compliance/MarketTransparency/P119958](http://www.finra.org/Industry/Compliance/MarketTransparency/P119958), and Chapman, P., 2010, “FINRA proposal riles OTC market,” *Traders Magazine Online News*, January 25, 2010, from [www.tradersmagazine.com/news/finra-pink-sheets-otc-markets-104992-1.html](http://www.tradersmagazine.com/news/finra-pink-sheets-otc-markets-104992-1.html).

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