Forgery, market liquidity, and demat trading: Evidence from the National Stock Exchange in India*

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Abstract

We analyse the impact of the introduction of a new technology on the National Stock Exchange in India that allowed trading of stocks without the need to transfer paper share certificates (demat trading). We document a decrease in the bid-ask spread following its introduction particularly for those stocks that were previously illiquid. We present evidence that suggests that the primary channel for the increase in liquidity was the elimination of the risk of being sold forged securities as the clearing system took on the risk of reimbursing buyers of forged shares at the introduction of demat trading.

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1 Introduction

On 26 December 96, the National Stock Exchange in India (NSE) introduced an innovation called de-materialised (demat) trading. This eliminated the need to transfer paper share certificates from seller to the buyer. Instead buyers and sellers would now hold an account in a centralised depository, much like a bank account, which would contain an account of their portfolio. At the conclusion of a transaction the security would now simply be 'debited' from the seller's account and 'credited' to the buyer's account.

One of the reasons for the adoption of demat trading was the circulation of forged paper share certificates. It was hoped that a shift to the electronic demat form would eliminate the effect of their existence on trading. Prior to the adoption of demat trading, buyers were wary of receiving forged shared certificates, and this naturally dampened trading. After the adoption of demat, the clearing system National Securities Clearing Corporation Ltd. (NSCCL) had a mechanism to implement its mandate of guaranteeing trades and settlements within three days. This meant that buyers were now fully insured against the possibility of receiving forged share certificates, as the clearing system would step in to ensure they were delivered authentic shares in demat form.

Our paper is related to the large literature on how reforms of the trading process, governance structures, and technological innovations in a stock exchange affect market liquidity, the settlement of transactions, the delivery of shares and the overall trading infrastructure.[1] However, the number of historical instances of a major overhaul of

[1]See Cumming, Johan, and Li (2011), Foucault, Pagano, and Röell (2013), Hail and Leuz (2006), and Hasbrouck (2007) for examples and details.

an older stock exchange or the creation of a new one remain rare. We study one such instance – the creation of the NSE and more particularly its adoption of demat trading.

The NSE was created at a time when the Bombay Stock Exchange (BSE) was mired in allegations of fraud. Interestingly, at around the same time, the NASDAQ in the US was also in the spotlight thanks to a fallout resulting from Christie and Schultz (1994). The paper documented the avoidance of odd-eights quotes by the NASDAQ market makers and suggested that the dealers colluded tacitly to maintain a wide bid-ask spread. The attention caused by these findings led to a scrutiny of the NASDAQ by the Department of Justice and the SEC. This led to a series of phased reforms such as the separation ownership and operation of the NASDAQ and ultimately the change in the market microstructure in favour of limit order book. Dissemination of limit orders, quoted prices, and greater integration across rival exchanges, created a competitive environment reducing the importance of the existing dealer markets. The phased market reforms, primarily targeted at the NASDAQ, also helped the whole system of trading to adapt to the new environment.

Following Christie and Schultz (1994), several papers have investigated the impact of these reforms in the US on the bid-ask spreads, execution and transaction costs and other measures of market liquidity.[2] This literature suggests that the reforms led to a decrease in the bid-ask spread, and an increase in the intra-day volume at both the NYSE and the NASDAQ.

Our paper is related to this literature but the key difference lies in the nature of the market manipulation and the channel through which the reforms effectively eliminated them. Most of the reforms instituted in the US were also concurrently adopted in

[2]See for example Barclay (1997), Barclay et al. (1999), Bessembinder (1999), Bessembinder and Kaufman (1997), and Weston (2000).

India[3]. However, we focus on the introduction of a unified system of record keeping of the accounts in the electronic platform via demat trading and the subsequent changes in the delivery and the settlement process and find that these were the key drivers in eliminating manipulation leading to lower bid-ask spreads.

We construct a simple model to analyse how the presence of forged shares may affect trading. Taking the predictions of this model to the data we find that the adoption of demat trading had a large effect on the liquidity of securities as measured by the bid-ask spread. In particular we find that on average the bid-ask spread dropped by around 60%. Moreover, consistent with the model, we find that the drop was greater for those firms that had the higher bid-ask spread before the adoption of demat trading. We also find that the trading volume and the number of transactions increased by about 15% at the NSE relative to the Bombay Stock Exchange (BSE) for the same period. We also find that there is a disproportionate increase in the volume and the number of transactions for firms with a higher bid-ask spread pre-demat.

2 Historical background

Set up in 1875, the Bombay Stock Exchange (BSE) was Asia's first stock exchange and a milestone in India's capital market history. By the early 1990s its reputation had suffered after several scandals ranging from the manipulation of stock prices to outright fraud in delivery and settlement (see Shah and Thomas 1999). Perhaps the best example of this was the 1992 Indian stock market scam, a mega scandal that revealed that the BSE index was artificially propped up by 145% . When this was finally caught and exposed, the stock market collapsed and the banking system was

[3]See Table 5 in Appendix A for the timeline of reforms in India

made poorer by INR 40 billion.[4] The impact was far-reaching as it destroyed the trust and confidence of investors in the stock market. The lack of a robust regulatory framework discouraged many investors from participating in the stock markets.

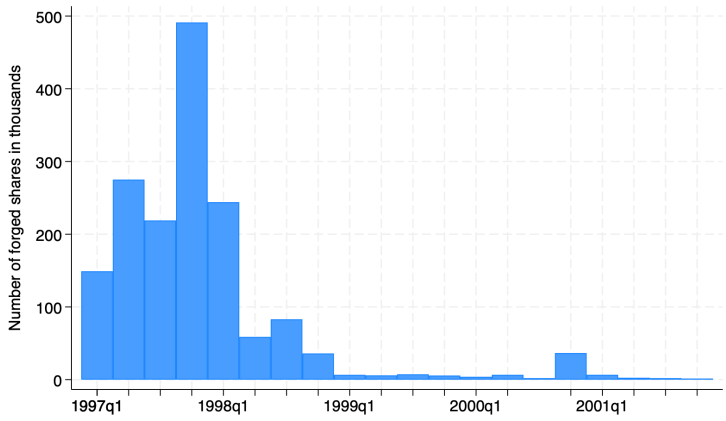
There were systemic agency problems between principals (buyer/sellers) and their brokers that affected the placing of orders, as well as the settlement and delivery process. For example, the only price information that was made available to the principals was the highest and lowest daily price. Brokers could therefore pocket the difference between the actual transacted price and the one they reported to their principals. There were also several incidents of forged share certificates being transacted and the buyer would have to wait for months before knowing whether the security he had purchased was fake. Figure 1 shows the number of fake or forged shares that buyers brought to the notice of the BSE between 1997 and 2001.[5] In our conversations with people who were active in the establishment of the NSE we were told that sometimes the corporates were themselves instrumental in circulating their own forged shares. As a result, the markets saw a relatively high bid-ask spread reflecting illiquidity of the stocks in both primary and secondary markets.

In response to these problems, the government appealed to the BSE to institute reforms. But the BSE was owned by brokers who resisted these reforms as they stood to lose the rents they received from the status quo. This led the government to create a new exchange known as the National Stock Exchange (NSE) that would address the malpractices rooted in the nature of the ownership and the market microstructure responsible for methods of trading, delivery, and accounts at the BSE. The NSE, which

[4]See Gupta (1992), Krishnamurti, Sequeira, and Fangjian (2003), Shah and Thomas (1999) and Thomas (2006) for excellent descriptions of these scandals.

[5]This data was shared with us by the BSE. The data on earlier years would have been relevant for our study but was not available.

Figure 1: Forgeries at the BSE



Number of fake or forged shares (divided by 1000) submitted as bad delivery by buyer brokers with the BSE between Feb 1997 and Dec 2001.

came into operation in November 1994, was India's first demutualised exchange, that is, unlike the BSE, it was not owned by the brokers. Moreover, as we will see, the new institution relied heavily on adoption of new technologies to weed out malpractices of the brokers.

The new exchange incorporated a wide range of new features including methods of trading, payment and settlement. Moreover, the governance structure of the NSE was very different from that of the BSE. While the BSE was owned by the brokers, the new NSE was set up by large financial institutions backed by the government. A series of studies have examined these reforms.[6] Important and cutting edge changes were made to both technological and organisational design of the stock market. Table 1 below summarises the timeline of key reforms undertaken in the period.[7] Over the years increased competition from the NSE would force the BSE to institute similar reforms to remain competitive – In the timeline presented in Table 1 we observe how

[6]See Krishnamurti, Sequeira, and Fangjian (2003), Gupta (1992), Rajan and Shah (2005), Shah and Thomas (1999), Thomas (2006) among others.

[7]Table 5 gives a more comprehensive treatment of the financial markets reforms.

Table 1: Timeline

12 April 1992	The Securities and Exchange Bureau of India is created by an act of parliament. This body regulates the capital markets in India.
11 November 1994	NSE begins to function. The NSE is established as an online trading platform.
14 March 1995	Online trading introduced at the BSE. For a transaction to be completed the seller must physically deliver the share certificates to the buyer.
October 1995	NSE overtakes the BSE and becomes the largest stock exchange in India.
April 96	National Securities Clearing Corporation Ltd. (NSCCL) is established. It has the mandate to act as a market participant who takes on the risk of the counterparty default and ensures that the payments are performed even in case of default.
26 December 1996	Demat trading begins on the NSE. This gives the NSCCL a mechanism to make good on its mandate to compensate buyers for delivery of fake shares by exchanging these for authentic shares in a demat form.
29 December 1997	Demat trading begins on the BSE.

in this period the NSE was always the first mover in innovation and the BSE was a follower. The reform that we focus on is the institution of demat trading at the NSE that commenced on the 26th of December 1996.

3 Model

In this section we construct a simple model based on the Lemons Model (Akerlof 1970). We derive testable implications that we take to the data in Section 4. We model a perfectly competitive market with dealers (market makers) who quote a price for buying and selling any stock, and there is a measure 1 of traders (sellers) each holding one security, who decide whether to sell the security at a price quoted by the dealers. Although we use the dealer market to ease the analysis, we should note that the NSE is an auction market.[8]

The value of an authentic security of firm i is commonly known to be $v_i > 0$. There is a fraction γ_i of forged securities for firm i with 0 value. Whether a security is forged or authentic is only privately observable to the seller.

The sellers with forged securities are willing to sell for any price $p_i \geq 0$. The willingness to sell for traders of authentic securities is distributed on the interval $[0, v_i]$ according to some cdf $s(p_i, v_i)$. This implies that all traders are willing to sell when offered v_i. When the dealer offers a price $p_i < v_i$ only a fraction $s(p_i, v_i)$ of the traders with authentic securities are willing to sell and being the cdf, $s(p_i, v_i)$ is increasing in p_i. This captures the idea that there may be liquidity sellers with heterogenous willingness to sell, and consequently the number of sellers is increasing in p_i.

[8]We expect our results to go through without this simplification. For a deeper discussion of dealer vs. auction market see Foucault, Pagano, and Röell (2013) and Huang and Stoll (1996).

Normalizing the total number of shares for all firms to 1 the total supply of securities for firm i is

$$\begin{array}{c} 1 \text{ if } p_i \geq v_i \\ \gamma_i + (1-\gamma_i)s(p_i, v_i) \text{ if } v_i > p_i \geq 0 \end{array} \tag{1}$$

Let $\hat{v}_i(p_i)$ be the expected value of a security as a function of its price. Using the supply above we find

$$\hat{v}_i(p_i) = \begin{cases} (1-\gamma_i)v_i & \text{if } p_i \geq v_i \\ \frac{(1-\gamma_i)s(p_i,v_i)v_i}{\gamma_i+(1-\gamma_i)s(p_i,v_i)} & \text{if } v_i > p_i \geq 0 \end{cases} \tag{2}$$

The dealers only buy securities of firm i as long as $\hat{v}_i(p_i) \geq p_i$. Perfect competition among dealers drives the profits down to 0. Hence dealers are willing to sell[9] for price $p_i^S = v_i$, and buy at a price $p_i^B = \hat{v}_i(p_i^B) = \frac{(1-\gamma_i)s(p_i^B,v_i)v_i}{\gamma_i+(1-\gamma_i)s(p_i^B,v_i)}$. Using this we can compute S_i, the bid-ask spread for firm i, which will be our outcome variable of interest.

$$S_i = \frac{p_i^S - p_i^B}{v_i} = \frac{\gamma_i}{\gamma_i + (1-\gamma_i)s(p_i^B, v_i)} \tag{3}$$

Note that the bid-ask spread is increasing in the fraction of shares that are forged. That is

$$\frac{\partial S_i}{\partial \gamma_i} = \frac{s(p_i^B, v_i)}{(\gamma_i + (1-\gamma_i)s(p_i^B, v_i))^2} - (1-\gamma_i)\frac{\partial s(p_i^B, v_i)}{\partial p_i^B}\frac{\partial p_i^B}{\partial \gamma_i} > 0, \tag{4}$$

as $\frac{\partial p_i^B}{\partial \gamma_i} < 0$.

Once demat trading was adopted NSCCL, the clearing system established earlier

[9]We assume that the dealers, being market makers, do not knowingly sell fake securities.

in the year could ensure that buyers were fully compensated with authentic shares in demat form in case they were sold forged ones. Hence from the buyer's point of view the existence of forged shares was eliminated. We therefore treat the introduction of demat as an innovation that eliminates the existence of forged share certificates. Hence post demat we have $\gamma_i = 0$ for all i. Consequently post demat we have $S_i = 0$ for all firms.[10] This simple model gives us two testable implications that we take to the data.

Testable Implication 1. *There is a drop in the bid-ask spread after the introduction of demat trading. The magnitude of the drop is increasing in γ_i, the fraction of shares of firm i that are forged.*

Testable Implication 2. *There is an increase in the number of transactions after the introduction of demat trading. The magnitude of the increase is increasing in γ_i, the fraction of shares of firm i that are forged.*

4 Empirics

In this section we present our empirical results. Section 4.1 describes the data we use. In section 4.2 we take the testable implication from section 3 to the data. Finally, in section 4.3 we discuss alternative explanations of the results.

[10]This prediction that the bid-ask spread goes to 0 after the introduction of demat trading is an artefact of the stylised nature of the model. In the model the only factor that creates the spread is the presence of forged shares. The model could be extended such that part of the spread is caused by other exogenous factors. This would mean that after the introduction of demat trading the spread would still drop but not to zero.

Table 2: Summary Statistics

	Mean	SD	Min	Max
Bid-ask spread (negative to 0) NSE	2.66	5.14	0	192.98
Bid-ask spread (negative to missing) NSE	4.10	5.90	0	192.98
Volume (Shared traded in thousands) NSE	36.41	509	0	51729.75
Number of transactions NSE	91.10	882.3	0	80662
Volume (Shared traded in thousands) BSE	23.40	247.8	0	15637.55
Number of transactions BSE	53.07	454.1	0	25167
Observations	1039785			

The unit of observation is firm-day. There are 1037 firms in the sample over a period of 4 years. The bid-ask spread variables are constructed using Corwin and Schultz (2012) who propose two ways of addressing negative bid-ask spreads – setting the negative values to 0 or dropping the observations where the estimated values are negative.

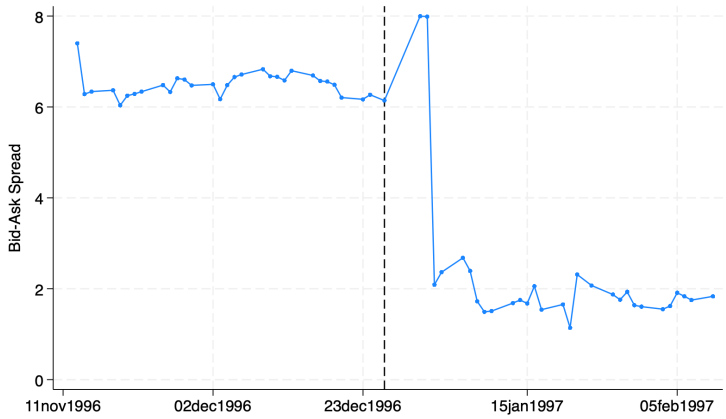
4.1 Data

Our data comes from the Prowess dataset compiled by the Centre for Monitoring Indian Economy. This dataset has been described as the Indian equivalent of CRSP/Compustat (Naaraayanan and Nielsen 2021) and has been widely used in academic literature involving Indian firms.[11] Our sample comprises of the 1038 firms that were listed on both the BSE and the NSE from 1 January 1995 to 31 December 1998. Table 2 reports the summary statistics.

We construct the bid-ask spread, our main dependent variable, using a measure proposed in Corwin and Schultz (2012). This measure uses the daily high and low prices to compute the bid-ask spread based on the idea that the high price is almost always

[11] See for example Bertrand, Mehta, and Mullainathan (2002), Gopalan, Nanda, and Seru (2007), Gopalan, Nanda, and Seru (2014), and Siegel and Choudhury (2012).

Figure 2: Bid-Ask Spread on the NSE



This figure shows the bid-ask spread at the NSE 30 trading days before and after the introduction of demat at the NSE. The bid-ask spread is averaged for each day over the firms in our sample. The vertical line indicates 26th of December 1996, the date on which demat trading was introduced at the NSE.

a buy trade and the low price is almost always a sell trade. Corwin and Schultz (2012) show that this estimator generally outperforms other low-frequency estimators.[12]

4.2 Results

We start with Figure 2, which shows the average liquidity at the NSE over a period of 30 trading days before and after the introduction of demat trading. The vertical red line indicates 26th December 1996, the day on which demat trading began. Consistent with Implication 1, we find that there is indeed a decline in the average bid-ask spread.

To test this formally, we run the following regression

$$y_{it} = \alpha_i + \gamma \text{Demat NSE}_t + X'_{it}\delta + \epsilon_{it}, \tag{5}$$

where α_i are the firm fixed effects, X_{it} is the trading volume as measured by the

[12]Our data only reports the daily high-low and opening-closing prices. The intra-day data on ticks is not available for the time period we analyze and consequently we cannot use high-frequency estimators.

number of shares traded in billions, and γ is the coefficient of interest. We multiply the dependent variable by 100 so that the coefficients can be interpreted as percentage point changes.

The results are reported in Table 3. Estimating with a 20 day trading window on either side we find that there is a 3.83 percentage point drop in the bid-ask spread. Since the average spread is 6.54 percent, the creation of demat leads to an almost 60% drop, which is substantial. To ensure that our results are robust, we run this regression while varying the window of time from ± 30 to ± 5 trading days. In these regressions we also control for the trading volume, and the day of the week dummies (five dummies – one for each working day of the week). Although the magnitude of the effect increases with the length of the window, we find that the results are statistically significant even when we use 5 days before and after demat adoption for our estimation.

Implication 1 predicts that there is not only an average decline in the bid-ask spread, but that the effects are stronger for stocks that are less liquid. To test this hypothesis we begin with Figure 3. In this figure we plot the bid-ask spread by quartiles based on how liquid the stock was two months prior to the introduction of demat trading. We note that the decline in the bid-ask spread is greatest for the least liquid firms.

To test this formally we run the following regression

$$y_{it} = \alpha_i + \beta_t + \lambda(\text{Demat NSE}_t \times \text{Past Spread Mean}_i) + X'_{it}\delta + \epsilon_{it}, \tag{6}$$

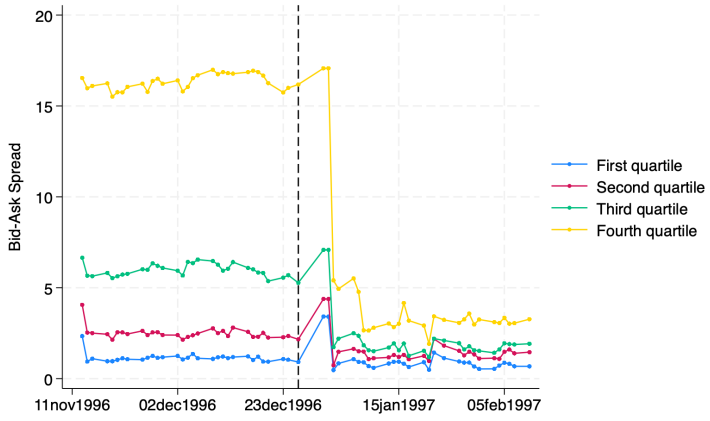
where y_{it} is the bid-ask spread of firm i on day t measured using the Corwin and Schultz (2012) estimator. Past Spread Mean measures the average spread for the firm from $T-50$ to $T-20$ where T is 26 Dec 1996, the day on which demat trading began.

Table 3: Effect of Introduction of Demat at NSE on Liquidity

	(1) ± 30 Days	(2) ± 25 Days	(3) ± 20 Days	(4) ± 15 Days	(5) ± 10 Days	(6) ± 5 Days
Demat NSE	−4.11***	−3.99***	−3.83***	−3.57***	−2.88***	−0.89***
	(0.21)	(0.20)	(0.20)	(0.19)	(0.17)	(0.11)
NSE Volume	−3.66	−40.59	−108.76	−229.56	−453.23*	−270.48*
	(103.57)	(99.48)	(125.81)	(152.82)	(193.18)	(105.45)
Constant	6.25***	6.21***	6.18***	6.25***	6.16***	6.18***
	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)
N	62278	51898	41518	31138	20758	10378

Dependent variable is the bid-ask spread at the NSE. The regression in each column is run on a sample with successively fewer days, with the number of days indicated in the column header. Standard errors clustered at the firm level are shown in parentheses. All specifications include day of week dummies, firm fixed effects, and the trading volume on the NSE and BSE. $^{+}$ $p < 0.10$, * $p < 0.05$,** $p < 0.01$, *** $p < 0.001$

Figure 3: Bid-Ask Spread by Quartile



This figure shows the average bid-ask spread on each day at the NSE for the four quartiles. A firm is classified into one of the four quartiles based on where its average bid-ask spread before demat was introduced lies in relation to the distribution. The vertical line indicates 26th of December 1996, the date on which demat trading was introduced at the NSE.

Table 4: Differential Effect of Introduction of Demat

	(1)	(2)	(3)	(4)	(5)
Demat NSE	-3.83^{***}	-3.83^{***}	-3.83^{***}		
	(0.20)	(0.09)	(0.09)		
Demat NSE ×		-0.81^{***}	-0.81^{***}	-0.81^{***}	-0.95^{***}
Past Spread Mean		(0.03)	(0.03)	(0.03)	(0.02)
NSE Volume			-188.13^{**}	61.56	-30.22
			(67.19)	(42.84)	(38.59)
Constant	6.54^{***}	6.54^{***}	6.54^{***}	1.87^{***}	2.69^{***}
	(0.10)	(0.04)	(0.05)	(0.11)	(0.09)
Day fixed effect	*No*	*No*	*No*	*Yes*	*Yes*
Firm linear trend	*No*	*No*	*No*	*No*	*Yes*
N	41518	41518	41518	41518	34642

Dependent variable is the bid-ask spread at the NSE. The sample consists of ± 20 days from the introduction of demat trading at NSE. All regressions include firm fixed effects. Standard errors clustered at the firm level are shown in parentheses. $^{+}$ $p < 0.10$, * $p < 0.05$,** $p < 0.01$, *** $p < 0.001$

We normalise this variable to have mean zero. The results are reported in columns 2-5 in Table 4. Column 1 replicates the results from Table 3 for comparison. In columns 2 and 3 we note that the coefficient on the interaction term is negative and significant indicating that the decline in the bid-ask spread is greater for the firms with a larger bid-ask spread prior to adoption of demat trading.

The advantage of the specification in Equation (6) is that we can control for day fixed effects, that is, one dummy for each day in our sample. In columns 4 we include these in the regression and find that the estimate for λ is unchanged. Next, we control

for the firm specific volume of trade on the NSE in column 4. Finally, in column 5, we include firm specific linear time trends and find that the results are unaffected.

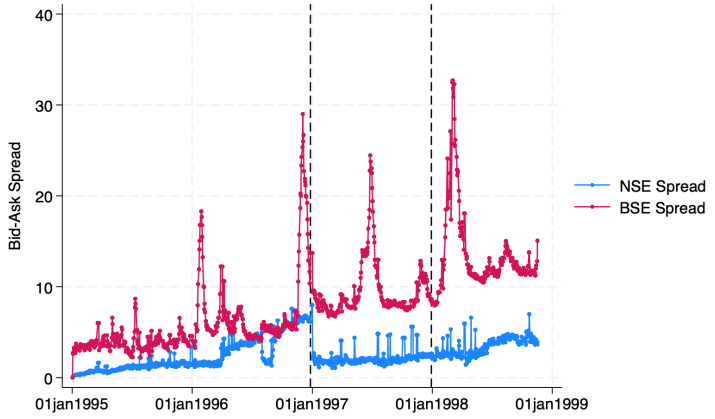
In the regressions reported in Table 4 we use a window of 20 trading days before and after the adoption of demat. To ensure that our results are robust to varying the time frame of analysis, we take the specification from column 4 and vary the window of time from ± 30 days to ± 5 days. The results, reported in Table 6 in Appendix B, confirm that the analysis is robust to varying the number of days included in the sample.

Next, we examine the effect of demat on the log shares traded. Based on Implication 2 we expect that this should increase with the adoption of demat, and the increase should be larger for firms that were less liquid at the start. The results, reported in Table 7, confirm this hypothesis. Similarly, we examine the effect of demat on the log number of transactions to examine whether there is an effect of demat and whether this effect is heterogeneous. The results, reported in Table 8, confirm that the effect is indeed greater for firms that are less liquid at the start.

It took the BSE one whole year to adopt demat trading after it was introduced at the NSE. This allows us to examine the adoption of demat trading affected outcomes on the NSE relative to the BSE. To start with, we present Figure 4 that shows the average bid-ask spread over all firms in our sample over from January 1995 to November 1998. The first vertical red line corresponds to the date of introduction of demat at the NSE and the next one corresponds to the date of introduction at the BSE. We notice that there is a clear drop in the bid-ask spread at the NSE relative to the BSE after demat trading is introduced. This gap persists over time and does not appear to be narrowed by the introduction of demat trading at the BSE a year later. It is interesting to note that unlike the NSCCL, the clearing house of the BSE had no mandate to insure

[ht]

Figure 4: Bid-Ask spread at the NSE and the BSE



This figure shows the average bid-ask spread on each day at the NSE and the BSE. The two vertical lines indicate 26th of December 1996 and 29th December 1997, the dates on which demat trading was introduced at the NSE and the BSE, respectively.

buyers against the risk of being sold fake securities. Consequently, the introduction of the same technology had no immediate effect on the liquidity on the BSE. In an extension of our model we analyse why the introduction of demat may not have had the same effect on the BSE. This can be found in Appendix C.

A natural specification that we could have tried in this setting is

$$Y_{it}^{NSE} - Y_{it}^{BSE} = \alpha_i + \gamma \text{Demat NSE}_t + X_{it}'\delta + \epsilon_{it}. \tag{7}$$

However, as we see in Figure 4, the volatility of the bid-ask spread at the BSE is high and one such episode of volatility corresponds to the date of adoption of demat trading at the NSE. Consequently, such results are likely to be misleading. Instead, we do this exercise with log number of shares traded and the log number of transactions. The results are reported in columns 3 and 6 of Tables 9 and 10. The results indicate that

in the days following the adoption of demat, the number of shares traded on the NSE relative to the BSE increased by between 11-15%. Similarly, the number of transaction increased by just over 15% at the NSE relative to BSE. These effects are economically significant.

Interestingly, in columns 2 and 5 in Tables 9 and 10, we note that there seems to be an increase in the number of shares traded, and transactions at the BSE after the introduction of demat at the NSE. One possible explanation of this could be that the volume of trade increased as investor confidence responded to the introduction of demat trading. The results suggest that this increased market activity somehow spilled over into the BSE. Nonetheless, the increase on these variables at the NSE was greater than on the BSE.

4.3 Alternative mechanisms

There are several channel through which demat may have affected liquidity (Raju and Patil 2001). Our explanation is based on a change in expectations of the buyers – the adoption of demat trading leads to the buyers expecting that they would be compensated in case they were sold fake securities. This channel particularly affects securities of firms that had a larger fraction of forged share certificates in the market, and were consequently less liquid. In this section we present alternative explanations of our results and argue that given the pattern of evidence we have presented, these are unlikely to explain the effects we have documented.

Endorsement and delivery The Registrar of Companies, a centralised government authority, had to endorse a certificate as being genuine for every transaction. The

process known as endorsement and delivery usually took at least 2 months. A period of 3-6 months was not uncommon. For demat transactions however, the endorsement was instantaneous as there was no need for verifying securities. It is reasonable to believe that this would have attracted traders who were previously repelled by the need to wait for a few months before selling securites they had bought. Consequently, it is possible that the elimination of the need for this process lead to a drop in the bid-ask spread.

It is unlikely that this is the channel that is driving our results. Raju and Patil (2001) note that even at the end of 1997, one year after the adoption of demat, demat market capitalization as a percentage of total market capitalization was just 0.11%.[13] As such, almost all securities were still transacted through paper share certificates. It is therefore unlikely, that the immediate drop in the bid-ask spread that we document was caused by the elimination of endorsement and delivery.

Indivisibility Before the adoption of demat there was a lower bound to the number of shares that could be traded since only share certificates for multiples of a certain amount existed. This would have excluded small investors interested in buying securities in smaller denominations. It is therefore possible that liquidity increased as more of such buyers participated in the NSE after the adoption of demat trading. Although this may have happened over the long run, we believe that this is unlikely to be driving our short run results.

First, as noted earlier, demat over this period accounted for a tiny proportion of transactions (around .11% at the end of 1997). Second, if this effect was large we should notice that the size of the average transaction at the NSE drops relative to the BSE as the smaller transactions migrate to the NSE. We test this prediction in

[13]This percentage was 3.85 by the end of 1998, 20.96 by the end of 1999, and 50.55 by the end of 2000.

Table 11 in Appendix B and we find that there is no such effect on the average trade.

Costs of transacting with paper Prior to demat, securities had to be physically transported to the location of trade. Moreover, there was the possibility of loss or theft of share certificates. This would lead to reduced liquidity of the securities which, the adoption of demat would have increased. As noted earlier, by the end of 1997, an year after demat trading was introduced, the demat market capitalization as a percentage of total market capitalization was only 0.11%. This indicates that there was only a tiny volume of trade that took place through the new technology. It is therefore unlikely that the drop in liquidity was a result of a drop in actual transaction costs. Moreover, the cost of handling physical securities should apply to all firms, and this does not explain the differential drop that we observe for the less liquid securities.

Differential stamp duty To incentivize trade in demat securities the Indian capital market regulator SEBI slashed the stamp duty of 0.5% charged for transfer of physical shares to zero for demat transactions. This may have increased the volume of trade and lead to a decline in the bid-ask spread. However, once again this explanation appears to be inconsistent with the fact that demat market capitalization remained very small even one year after the adoption of demat trading.

5 Conclusion

In December 1996 the NSE adopted the technological innovation of demat trading that allowed the trading of securities without the transfer of paper certificates. This enabled the clearing system to credibly insure buyers against the possibility of being

sold fake securities. Using a simple model based on asymmetry of information about the authenticity of the paper certificates between the sellers and buyers, we show that the adoption of demat trading will have strong effects on liquidity of securities, particularly for firms that have a greater fraction of forged certificates in the market.

Our empirical results are consistent with the prediction of the model. We find large effects that adoption of demat trading increased liquidity, the number of transactions, and the volume. We find that these large effects arose in a short period of time as these are significant even when examining a brief period of time of 20 days before and after the adoption of demat trading.

The NSE was created by the Indian government as a competitor to the BSE, which was believed to be captured by insiders. As such its creation is an example of an aggressive government intervention in the financial markets. In the years that followed, the NSE lead in adopting several technological and institutional innovations that were subsequently adopted by the BSE. By focusing on one such innovation, namely the adoption of demat trading, we have attempted to document a notable success story of government intervention in financial markets.

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A Timeline

Table 5: Extended timeline of events

Date	**Event**
02/02/1921	Clearing House started by the Bank of India. This was used for the Bombay Stock Exchange.
10/07/1987	Bombay Stock Exchange sets up the investor protection fund.
12/04/1992	Securities and Exchange Board of India was created.
03/11/1994	National Stock Exchange starts to function.
14/03/1995	Bombay Stock Exchange On-Line Trading (BOLT) system introduced – Before this information of prices were not available real time. This allowed brokers to extract rents by skimming off the difference between the price at which they actually sold a security and the price they quoted as being the "market price" to their client.
Jun 1995	Introduction of centralised insurance cover for all trading members at the National Stock Exchange.
Jul 1995	Introduction of Investor Protection Fund at the National Stock Exchange.
Oct 1995	National Stock Exchange becomes the largest stock exchange in India overtaking the Bombay Stock Exchange.
Dec 1995	National Securities Depository Limited is incorporated.

Apr 1996	Commencement of clearing and settlement by National Securities Clearing Corporation Limited (NSCCL) at the National Stock Exchange – In order to avoid counterparty risk of default a central counterparty (clearing house) is used which acts as a market participant who is taking the risk of the counterparty default and ensures that the payments are performed even in case of default. The NSCCL aggregates trades over a trading period, nets the positions to determine the liabilities of members and ensures movement of funds and securities to meet respective liabilities.
Jun 1996	Introduction of Settlement Guarantee Fund at National Stock Exchange. This institution is the equivalent of the Trade Guarantee Fund in Bombay Stock Exchange that was established in the following year.
Nov 1996	National Securities Depository Limited is inaugurated
26/12/1996	Commencement of Demat trading at the National Stock Exchange.
Feb 1997	Regional clearing facility goes live at the National Stock Exchange.
12/05/1997	Trade Guarantee Fund introduced in Bombay Stock Exchange.
21/07/1997	Broker's Contingency Fund introduced by the Bombay Stock Exchange.
1997	Bombay Stock Exchange On-Line Trading system expanded nation-wide.
29/12/1997	Commencement of Demat trading at the Bombay Stock Exchange.
Feb 1999	Launch of Automated Lending and Borrowing Mechanism at the National Stock Exchange.
01/06/1999	Interest Rate Swaps (IRS) / Forward Rate Agreements (FRA) allowed at the Bombay Stock Exchange.
15/07/1999	Central Depository Services Limited commences work at the Bombay Stock Exchange.

Feb 2000	Commencement of Internet Trading at the National Stock Exchange.
Jun 2000	Commencement of Derivatives Trading (Index Futures) at the National Stock Exchange.
16/05/2007	Corporatisaton and Demutualisation of the Bombay Stock Exchange.

[H]

Table 6: Robustness of the interaction coefficient with respect to the time window

	(1)	(2)	(3)	(4)	(5)	(6)
	± 30 Days	± 25 Days	± 20 Days	± 15 Days	± 10 Days	± 5 Days
Demat NSE ×	-0.85^{***}	-0.83^{***}	-0.81^{***}	-0.76^{***}	-0.66^{***}	-0.36^{***}
Past Spread Mean	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
NSE Volume	48.42	62.25^{+}	61.56	60.66	31.75	52.38
	(30.34)	(31.94)	(42.84)	(51.77)	(75.33)	(54.13)
Constant	1.83^{***}	1.55^{***}	1.87^{***}	1.54^{***}	1.51^{***}	2.36^{***}
	(0.10)	(0.11)	(0.11)	(0.15)	(0.12)	(0.16)
Day fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
N	62278	51898	41518	31138	20758	10378

Dependent variable is the bid-ask spread at the NSE. The regression in each column is run on a sample with successively fewer days, with the number of days indicated in the column header. Standard errors clustered at the firm level are shown in parentheses. All specifications include day fixed effect (one dummy for each day in our sample), firm fixed effects, and the trading volume on the NSE.$^{+}$ $p < 0.10$, * $p < 0.05$,** $p < 0.01$, *** $p < 0.001$

B Additional results

[H]

Table 7: Effect of demat on log shares traded

	(1)	(2)	(3)	(4)	(5)
Demat NSE	0.76***	0.76***	0.76***		
	(0.02)	(0.02)	(0.02)		
Demat NSE ×		0.03***	0.03***	0.03***	0.03***
Past Spread Mean		(0.00)	(0.00)	(0.00)	(0.00)
Constant	7.24***	7.24***	7.24***	7.54***	7.50***
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)
Day fixed effect	*No*	*No*	*No*	*Yes*	*Yes*
Firm linear trend	*No*	*No*	*No*	*No*	*Yes*
N	34642	34642	34642	34642	34642

Dependent variable is the log number of shares traded at the NSE. Sample composed of firm-days when non-zero shares were traded. The sample consists of ± 20 days from the introduction of demat trading at NSE. Standard errors clustered at the firm level are shown in parentheses. All specifications include firm fixed effects. $^{+}$ $p < 0.10$, * $p < 0.05$,** $p < 0.01$, *** $p < 0.001$

[H]

Table 8: Effect of demat on log number of transactions

	(1)	(2)	(3)	(4)	(5)
Demat NSE	0.69***	0.70***	0.70***		
	(0.02)	(0.02)	(0.02)		
Demat NSE ×		0.03***	0.03***	0.03***	0.03***
Past Spread Mean		(0.00)	(0.00)	(0.00)	(0.00)
Constant	2.22***	2.21***	2.21***	2.52***	2.48***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Day fixed effect	*No*	*No*	*No*	*Yes*	*Yes*
Firm linear trend	*No*	*No*	*No*	*No*	*Yes*
N	33858	33858	33858	33858	33858

Dependent variable is the log number of transactions at the NSE. Sample composed of firm-days with non-zero transactions. The sample consists of ± 20 days from the introduction of demat trading at NSE. Standard errors clustered at the firm level are shown in parentheses. All specifications include firm fixed effects. $^{+}$ $p < 0.10$, * $p < 0.05$,** $p < 0.01$, *** $p < 0.001$

[H]

Table 9: Effect on Shares Traded

	(1) NSE	(2) BSE	(3) Difference	(4) NSE	(5) BSE	(6) Difference
Demat NSE	0.77***	0.63***	0.15***	0.67***	0.57***	0.11***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
Constant	7.08***	6.77***	0.38***	7.14***	6.84***	0.37***
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
N	34642	32720	30025	25961	24612	22840

Dependent variable in column (1) and (4) is the log number of shares traded on the NSE. Dependent variable in column (2) and (5) is the log number of shares traded on the BSE. Dependent variable in column (3) and (6) is the difference between log number of shares traded on the NSE and log the number of shares traded on the BSE. Sample composed of firm-days when non-zero shares were traded on both exchanges. The dependent variable varies by firm and day. The regressions reported in the first three column use the sample restricted to $\pm$ 20 days from the introduction of demat and the last three columns use a sample restricted to $\pm$ 10 days. Standard errors clustered at the firm level are shown in parentheses. All specifications include day of week and firm fixed effects. $^{+}$ $p < 0.10$, * $p < 0.05$,** $p < 0.01$, *** $p < 0.001$

[H]

Table 10: Effect on the Number of Transactions

	(1) NSE	(2) BSE	(3) Difference	(4) NSE	(5) BSE	(6) Difference
Demat NSE	0.71***	0.55***	0.16***	0.61***	0.52***	0.15***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Constant	2.08***	1.76***	0.39***	2.12***	1.86***	0.50***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
N	33858	32034	29416	16071	15289	344581

Dependent variable in column (1) is the log number of transactions on the NSE. Dependent variable in column (2) is the log number of transactions on the BSE. Dependent variable in column (3) is the difference between the log number of transactions on the NSE and the log number of transactions on the BSE. The dependent variable varies by firm and day. The regressions reported in the first three column use the sample restricted to $\pm$ 20 days from the introduction of demat and the last three columns use a sample restricted to $\pm$ 10 days. Sample composed of firm-days when non-zero transactions took place on both exchanges. Standard errors clustered at the firm level are shown in parentheses. All specifications include day of week and firm fixed effects. $^{+}$ $p < 0.10$, * $p < 0.05$,** $p < 0.01$, *** $p < 0.001$

[H]

Table 11: The Effect of Demat on the Size of the Average Trade

	(1) NSE	(2) BSE	(3) Difference	(4) NSE	(5) BSE	(6) Difference
Demat NSE	-52.31^{*}	-123.8^{*}	93.98	-65.06^{*}	-126.4^{+}	112.1
	(20.59)	(54.12)	(61.80)	(25.49)	(73.04)	(79.87)
Constant	276.3^{***}	574.0^{***}	-333.5^{***}	304.1^{***}	599.3^{***}	-354.5^{***}
	(13.35)	(68.81)	(77.39)	(21.17)	(79.71)	(88.86)
N	33858	32034	29416	25364	24081	22354

Dependent variable in column (1) is the number of transactions on the NSE. Dependent variable in column (2) is the number of transactions on the BSE. Dependent variable in column (3) is the difference between number of transactions on the NSE and the number of transactions on the BSE. The dependent variable varies by firm and day. The regressions reported in the first three column use the sample restricted to $\pm$ 20 days from the introduction of demat and the last three columns use a sample restricted to $\pm$ 10 days. Sample composed of firm-days when non-zero transactions took place on both exchanges. Standard errors clustered at the firm level are shown in parentheses. All specifications include day of week and firm fixed effects. $^{+}$ $p < 0.10$, * $p < 0.05$,** $p < 0.01$, *** $p < 0.001$

[H]

Table 12: Coding negative spread values as missing

	(1)	(2)	(3)	(4)	(5)
Demat NSE	-3.43^{***}	-3.04^{***}	-3.03^{***}		
	(0.19)	(0.10)	(0.10)		
Demat NSE ×		-0.66^{***}	-0.66^{***}	-0.67^{***}	-0.83^{***}
Past Spread Mean		(0.03)	(0.03)	(0.03)	(0.02)
NSE Volume			-188.46^{**}	117.58^{*}	
			(70.25)	(53.94)	
NSE Volume					0.00
					(0.00)
Constant	8.13^{***}	8.04^{***}	8.05^{***}	3.30^{***}	3.92^{***}
	(0.08)	(0.04)	(0.04)	(0.16)	(0.13)
Day fixed effect	No	No	No	Yes	Yes
Firm linear trend	No	No	No	No	Yes
N	28970	28970.00	28970.00	28970.00	22641.00

Dependent variable is the bid-ask spread at the NSE where negative values are coded as missing. The sample consists of ± 20 days from the introduction of demat trading at NSE. All regressions include firm fixed effects. Standard errors clustered at the firm level are shown in parentheses. $^{+}$ $p < 0.10$, * $p < 0.05$,** $p < 0.01$, *** $p < 0.001$

C Extension: Demat at the BSE

The NSE and the BSE are the two main exchanges in India. As described earlier, the two exchanges used to differ in their ownership structure. During our sample period BSE was owned and operated by the brokers to maximise their own rents. Consequently, we may expect the effects of adoption of demat trading at the BSE to be different from the what we have seen at the NSE. To motivate our investigation of the effect of demat at the BSE we begin with an extension of the model presented in section 3.

Once again we model the exchange as a dealer market facing the same supply function presented in the expression in (1). However unlike the NSE we assume that the brokers at the BSE have market power. This market power is reflected in the fact that brokers can charge a mark up over the value of the stock. In particular, brokers can charge μv_i for a stock valued at v_i, where $\mu > 1$. Moreover, we assume that

$$\mu > \frac{1}{1-\gamma_i} \qquad \forall i. \tag{8}$$

Keeping all other ingredients of the model from Section 3 unchanged, the total supply of securities for firm i is

$$\begin{cases} 1 \text{ if } p_i \geq v_i \\ \gamma_i + (1-\gamma_i)s(p_i, v_i) \text{ if } v_i > p_i \geq 0 \end{cases} \tag{9}$$

Let $\hat{v}_i(p_i)$ be the average value of a security for the broker as a function of its price.

Using the supply above we find

$$\hat{v}_i(p_i) = \begin{cases} (1-\gamma_i)\mu v_i & \text{if } p_i \geq v_i \\ \frac{(1-\gamma_i)s(p_i,v_i)\mu v_i}{\gamma_i+(1-\gamma_i)s(p_i,v_i)} & \text{if } v_i > p_i \geq 0 \end{cases} \tag{10}$$

The dealers only buy securities of firm i as long as $\hat{v}_i(p_i) \geq p_i$. We continue to assume that dealers do not sell forged securities. Genuine securities are priced at $p_i^S = \mu v_i$, and bought at any price in the range $p_i^B \in [v_i, \mu v_i]$. To maintain the assumption that brokers have market power and μ is the mark up it is natural to set $p_i^B = v_i$. This implies that the bid-ask spread for firm i at the BSE is

$$S_i = \frac{p_i^S - p_i^B}{v_i} = \mu - 1. \tag{11}$$

Note that the bid-ask spread is invariant to the fraction of shares that are forged. This implies that introduction of demat at the BSE will have no effect on the bid-ask spread.