is likely to be driven by other reasons (e.g., see Laux 1995; Godek 1996; Huang and Stoll 1996; Grossman et al. 1997).

*Effect of Quote Clustering on Quoted Spreads*

Previous studies show that stocks with higher degrees of quote clustering have wider spreads (e.g., see Christie and Schultz 1994; Godek 1996; Barclay 1997; Chung, Van Ness, and Van Ness 2001). In this section, we examine whether the same pattern exists after decimalization. Specifically, we analyze how the quoted spread is related to quote clustering after controlling for other determinants of the spread that have been suggested in the literature, that is, share price, dollar trading volume, turnover rate (the number of shares traded divided by the number of shares outstanding), return volatility, and market capitalization. We measure the extent of quote clustering by the proportion of quotes that are divisible by 5 cents. Because quote clustering is also likely to be determined by stock attributes, we treat it as an endogenous variable.

Ball, Torous, and Tschoegl (1985), Harris (1991), and Grossman et al. (1997) maintain that traders use discrete price sets to lower the costs of negotiation, and negotiation costs will be low if traders use coarse price sets. If the price set is too coarse (i.e., the set does not include a price that is acceptable to both parties), however, lost gains from trade will be large. Ball, Torous, and Tschoegl suggest that the extent of clustering depends on the trade-off between negotiation costs and lost gains from trade. They suggest that lost gains from trade are likely to be large if little dispersion exists among traders' reservation prices, such as when the underlying security values are well known. Based on these observations, the authors predict that traders will use a fine set of prices when the underlying security values are well known.

We measure the reservation-price dispersion by return volatility, number of trades, trade size, market capitalization, and share price. Harris (1991) holds that stocks with higher return volatility or infrequent trading have larger reservation-price dispersion. We expect stocks with larger trade sizes to exhibit larger reservation-price dispersion because information asymmetry may be greater for such stocks. Stocks of smaller companies are likely to exhibit larger reservation-price dispersion because they are followed by fewer analysts and thus less information is available. Finally, we predict that high-price stocks exhibit larger price variations (and thus more clustering) than low-price stocks because traders are likely to use discrete price sets on the basis of minimum price variations that are constant fractions of price. Thus, we conjecture that quote clustering is positively related to return volatility, trade size, and share price, and negatively related to trading frequency and market capitalization.

Godek (1996) holds that higher quote clustering may be caused by dealers' desire to quote wider spreads to compensate for larger market-making costs, suggesting that quote clustering is likely to be higher for stocks with larger spreads.

Based on these considerations, we employ the following structural model as an empirical representation of the relation between the percentage spread (*SPREAD*) and quote clustering (*QC*):

$$SPREAD = \alpha_0 + \alpha_1(1/PRICE) + \alpha_2 \log(VOLUME) + \alpha_3 TURNOVER + \alpha_4 VOLATILITY + \alpha_5 \log(MVE) + \alpha_6 QC + \varepsilon_1, \quad (4)$$

$$QC = \beta_0 + \beta_1 \log(PRICE) + \beta_2 \log(NTRADE) + \beta_3 \log(TSIZE) + \beta_4 VOLATILITY + \beta_5 \log(MVE) + \beta_6 SPREAD + \varepsilon_2, \quad (5)$$

where *SPREAD* is the time-weighted percentage spread, *QC* is the proportion of quotes that are divisible by 5 cents, *PRICE* is the mean value of the midpoints of quoted bid and ask prices, *VOLUME* is the dollar trading volume, *TURNOVER* is the ratio of the number of shares traded to the number of shares outstanding, *VOLATILITY* is the standard deviation of daily returns calculated from the daily closing midpoints of bid and ask prices, *MVE* is the market value of equity, *NTRADE* is the number of trades, and *TSIZE* is the average dollar transaction size. We include dollar trading volume in lieu of number of trades and trade size in the spread equation to satisfy the rank and order conditions of identification. Note that dollar trading volume captures the joint effect of the latter two variables. Expected signs of regression coefficients are $\alpha_1 > 0$, $\alpha_2 < 0$, $\alpha_3 > 0$, $\alpha_4 > 0$, $\alpha_5 > 0$, $\alpha_6 > 0$, $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 > 0$, $\beta_4 > 0$, $\beta_5 < 0$, and $\beta_6 > 0$.

We report the three-stage least squares (3SLS) regression results in Table 5. The first two columns show the results for the NASDAQ sample and the next two columns show the results for the NYSE sample. As predicted, the extent of quote clustering is positively related to share price (*PRICE*), return volatility (*VOLATILITY*), and trade size (*TSIZE*), and negatively to the number of trades (*NTRADE*) and firm size (*MVE*) on both the NYSE and NASDAQ. These results are consistent with predictions of the theory of quote clustering advanced by Ball, Torous, and Tschoegl (1985) and Harris (1991). Consistent with the prediction of Godek (1996), we also find that quote clustering (*QC*) is positively and significantly related to the spread (*SPREAD*).

Consistent with the findings of prior studies, we find that the spread is negatively related to dollar trading volume (*VOLUME*) and positively to the reciprocal of share price (*PRICE*) and turnover rate (*TURNOVER*). The less prominent role of share price in the spread equation compared with that reported in Harris (1994) may reflect that the penny tick size is less frequently a binding constraint on spread widths. More important, we find that the percentage spread is significantly and positively related to quote clustering on both the NYSE and NASDAQ. The positive relation between the spread and the extent of quote clustering is consistent

**TABLE 5. A Structural Model of the Spread and Quote Clustering.**

| | NASDAQ | | NYSE | |
|---|---|---|---|---|
| Independent Variable | *SPREAD* | *QC* | *SPREAD* | *QC* |
| Intercept | 0.0072 | 0.153 | 0.0101 | −0.0393 |
| | (1.45) | (1.12) | (3.50***) | (−0.31) |
| 1/*PRICE* | 0.0143 | | 0.0171 | |
| | (1.71) | | (3.80***) | |
| log(*VOLUME*) | −0.0032 | | −0.0023 | |
| | (−10.91***) | | (−12.97***) | |
| *TURNOVER* | 0.0032 | | 0.0025 | |
| | (2.33**) | | (3.39***) | |
| *VOLATILITY* | 0.0162 | 1.0197 | 0.0026 | 0.9383 |
| | (0.96) | (2.20**) | (0.25) | (2.00**) |
| log(*NTRADE*) | | −0.0632 | | −0.0804 |
| | | (−2.55***) | | (−4.16***) |
| log(*TSIZE*) | | 0.0752 | | 0.1440 |
| | | (3.95***) | | (8.25***) |
| log(*PRICE*) | | 0.1175 | | 0.1485 |
| | | (11.13***) | | (7.74***) |
| log(*MVE*) | 0.0039 | −0.0265 | 0.0034 | −0.0669 |
| | (4.98***) | (−1.94**) | (7.85***) | (−4.61***) |
| *QC* | 0.0713 | | 0.0321 | |
| | (16.17***) | | (17.78***) | |
| *SPREAD* | | 7.2356 | | 18.2742 |
| | | (2.37**) | | (5.20***) |
| System-weighted $R^2$ | 0.628 | | 0.676 | |
| System-weighted mean square error | 8.323 | | 10.203 | |

Note: This table shows the three-stage least squares (3SLS) results of the following structural model:

$$SPREAD = \alpha_0 + \alpha_1(1/PRICE) + \alpha_2 \log(VOLUME) + \alpha_3 TURNOVER + \alpha_4 VOLATILITY + \alpha_5 \log(MVE) + \alpha_6 QC + \varepsilon_1,$$

$$QC = \beta_0 + \beta_1 \log(PRICE) + \beta_2 \log(NTRADE) + \beta_3 \log(TSIZE) + \beta_4 VOLATILITY + \beta_5 \log(MVE) + \beta_6 SPREAD + \varepsilon_2,$$

where *SPREAD* is the time-weighted percentage spread, *QC* is the proportion of quotes that are divisible by 5 cents, *PRICE* is the mean value of the midpoints of quoted bid and ask prices, *VOLUME* is the dollar trading volume, *TURNOVER* is the ratio of the number of shares traded to the number of shares outstanding, *VOLATILITY* is the standard deviation of daily returns calculated from the daily closing midpoints of bid and ask prices, *MVE* is the market value of equity, *NTRADE* is the number of trades, and *TSIZE* is the average dollar transaction size. Numbers in parentheses are *t*-statistics.

*** Significant at the 1% level.
** Significant at the 5% level.

with the finding of Christie and Schultz (1994). This result contradicts the findings of Huang and Stoll (1996) that after controlling for differences in economic factors, no relation exists between quoted spreads and the frequency of odd-eighth quotes among their sample of 66 paired NYSE-NASDAQ stocks.

Although the results of the present study are similar to those of Christie and Schultz (1994) in that the spreads are positively related to the extent of quote clustering, the similarity between the two results may be due to different reasons. In Christie and Schultz, the high frequency of even-eighth quotes is claimed to be a reflection of dealers' collusive behavior to maintain supracompetitive spreads. Hence, in this case, it is the dealers' desire to maintain larger spreads that causes quote clustering. In our framework, the positive correlation between spreads and quote clustering may largely be an unintended outcome of investor preference toward nickel and dime quotes.[5] For example, if all of the market makers and limit-order traders use only nickel and dime quotes, the quoted spread will be at least 5 cents. On the other hand, if these liquidity providers do not exhibit such a preference and thus each quote increment is equally likely, the minimum spread is 1 cent. These considerations suggest that the observed spread is likely to be positively related to the proportion of nickel and dime quotes.

## V. Summary and Conclusion

Numerous studies suggest that execution costs on NASDAQ are significantly greater than those on the NYSE. Some researchers maintain that NASDAQ dealers implicitly collude to set larger spreads than their counterparts on the NYSE. Both academic research and anecdotal evidence suggest that execution costs for both NASDAQ and NYSE issues have declined significantly after decimalization. In this study, we perform a post-decimalization comparison of NASDAQ and NYSE trading costs.

Our empirical results show that the mean spreads of small NYSE companies are narrower than those of comparable NASDAQ companies when spreads are equally weighted across stocks. In contrast, the mean spreads of large NASDAQ companies tend to be narrower than those of comparable NYSE companies when spreads are volume weighted across stocks. These results are consistent with the finding of Bessembinder (Forthcoming) from a sample of NYSE and NASDAQ stocks that are matched based on market capitalization. We interpret these results as evidence that NYSE specialists' affirmative obligations to maintain reasonable spreads in their specialties provide low-cost executions for small, low-volume stocks whereas the competitive dealer system provides low-cost executions for large, high-volume NASDAQ stocks. Our results show that the prevalence of even-sixteenth quotes has largely been replaced by ubiquitous nickel and dime quotes after decimalization. We find that stocks with higher degrees of quote clustering have wider

[5]We cannot rule out the possibility that the high proportion of nickel and dime quotes reflects, at least in part, some market makers' desire to maintain wider spreads. We present an alternative theory of quote clustering.

spreads on both the NYSE and NASDAQ. We interpret this result as an unintended outcome of investor preference toward nickel and dime quotes for certain stocks.

We examine only the difference in spread between NASDAQ and NYSE stocks. As shown in Lee, Murklow, and Ready (1993), however, it is important that we consider both the price and quantity dimensions of dealer quotes to accurately measure liquidity. We were not able to perform depth comparison between the two markets because the TAQ database reports only the largest, not the aggregate, depth at the inside market for NASDAQ issues, whereas it reports the aggregate depth (specialist depth plus all of the limit orders at the quoted price) for NYSE issues. Hence, the intermarket comparison of quoted depths is not meaningful with TAQ data. A fruitful area for future research would be the intermarket comparison of liquidity that considers both dimensions (i.e., spread and depth) of dealer and limit-order quotes.

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