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Disclosure of information on order execution practices of market centers: How can investors utilize it?

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Abstract

The U.S. Securities and Exchange Commission has recently adopted Rule 11Ac1-5 that requires market centers to disclose statistical information regarding their order execution practices. The rule enables investors to assess the quality of execution for different types and sizes of orders in market centers. This paper develops a framework for comparing order execution quality across competing market centers by utilizing the data set made available as a result of the new rule. Different investors may have different preferences related to the execution quality of their orders. Our framework allows investors to incorporate their preferences as well as order types and sizes into the measurement of execution quality. © 2004 Academy of Financial Services. All rights reserved.

Jel classification: G10; G18; G20

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1. Introduction

The comparison of order execution quality across different securities market centers has been a central issue in market microstructure studies and in a recent rule of the U.S. Securities and Exchange Commission (SEC). In today's markets, investors demand the best execution of their orders from competing market centers, and a key service of market centers

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is to provide the highest quality for trade executions. Therefore, execution quality directly reflects market quality.

Execution quality for investors is commonly measured by execution costs. The difference between the ask and bid prices (dollar spread), and the difference between the execution price and the midpoint of the ask and bid prices are common measures of execution costs. Realized spread, measured by the transaction price relative to the midpoint of the bid and ask prices at some time subsequent to the trade, is also commonly used as a proxy for execution costs. Realized spread impounds the price movements after the trade and measures the potential loss to a dealer or a trader taking the other side of the order. Execution quality also has other dimensions such as speed of transaction, which is the difference between the time a broker receives an order from a customer and the time the order is executed, and the extent to which an order is executed for the full size at the best available price. A proper comparison of trading across market centers is dependent on the availability of standardized data on various measures of execution quality. Acknowledging this fact, the SEC introduced Rule 11Ac1-5 to increase the transparency of order execution practices of market centers (see the SEC Final Rule: Disclosure of Order Routing and Execution Practices, SEC, 2001). Rule 11Ac1-5 became effective on January 30, 2001, and market centers began publishing monthly data on execution quality in June 2001.

In this study, we provide a framework for the comparison of execution quality among different market centers using the data made available as a result of Rule 11Ac1-5. Our framework highlights the Analytic Hierarchy Process (AHP), which is a widely used tool for solving multi-attribute decision problems. Given that the assessment of execution quality involves measurements based on multiple criteria, it can apparently be difficult for an individual investor to decide which market provides the most desirable execution of an order. By using the AHP framework, investors can rank market centers based on the relative importance they assign to each execution quality criterion. More importantly, the AHP ensures consistency in the determination of the relative importance of the criteria. This is the first study that provides an analytical decision process for the comparison of market centers.

In the following section, we include a literature review for the execution quality of markets and discuss Rule 11Ac1-5. We provide an overview of the AHP in Section 3. In Section 4, we present an example in which we recommend a suitable order type and a market center to a hypothetical investor using the AHP. We provide a summary in Section 5.

2. Comparison of execution quality in market centers and Rule 11Ac1-5

Studies that analyze the quality of market centers primarily focus on measures of execution price quality such as percentage spread and effective spread, and report significant differences in these measures across market centers. Christie and Schultz (1994) find that National Association of Securities Dealers Automated Quotation System (Nasdaq) dealers avoided odd-eight quotes in 70 of the 100 largest Nasdaq stocks in 1991, leading to higher percentage spreads for those stocks. Using the Trades, Orders, Reports, and Quotes (TORQ) Database that covers 144 randomly selected NYSE stocks from November 1990 through January 1991, Chung et al., (2001) also show that the average Nasdaq spread was signifi-

cantly larger than the average New York Stock Exchange (NYSE) specialist's spread because of a higher use of even-eighth quotes of Nasdaq market makers. Moreover, Christie and Huang (1994) and Barclay (1997) report that spreads decrease when stocks move from Nasdaq to the NYSE. Bessembinder (1999) finds that spreads on Nasdaq are greater than those of the NYSE after the 1997 Nasdaq market reforms. Heidle and Huang (2002) suggest that informed traders who want to be anonymous prefer to trade in dealer markets rather than in an auction environment, and this leads to wider spreads in dealer markets such as Nasdaq. The SEC's Report on the Practice of Preferencing (SEC, 1997) finds significant differences in execution quality among the NYSE and the regional exchanges.

Based on these findings, it is important for investors to be able to compare market centers for the quality of execution of their orders. Rule 11Ac1-5 is intended to increase access to information about how securities transactions are executed, hence enhancing investors' ability to make choices on the basis of execution criteria important to their particular needs. Rule 11Ac1-5 states that "market centers that trade national market system securities (specialists, over-the-counter "OTC" market makers, and ATSs) would be required to make available to the public monthly electronic reports that include uniform statistical measures of execution quality on a security-by-security basis." As a result of Rule 11Ac1-5, investors now have access to uniform statistics of order execution quality provided by each market center. Although the availability of such information is very valuable, it is difficult especially for individual investors to act on it without a proper framework. We suggest that information on the performance of competing market centers can be utilized in a multi-attribute evaluation framework in which investors can rank various market centers based on a set of performance criteria. Full-service brokerage firms, on-line brokers, and financial planners can offer a service that uses the AHP to help investors identify a market center and an order type that are suitable to their personal needs and preferences. Such a service would be useful not only as an evaluation framework but also as a reliable repository of the disclosure data.

3. Using the AHP for evaluating the execution quality of market centers

The AHP, which was developed by Saaty (1977, 1980), is a tool that helps decision-makers solve complex multi-attribute problems. It is commonly used to rank competing alternatives based on a set of evaluation criteria, and it has been applied to a variety of problems in finance, such as determining investor suitability (Bolster et al., 1995), selecting mutual funds (Saraoglu & Detzler, 2002), assigning sovereign debt ratings (Johnson et al., 1990), selecting a life insurance contract (Puelz, 1991), and determining an optimum portfolio mix (Khaksari et al., 1989).

Comparison of execution quality in markets centers and making choices on the basis of execution criteria are typical multi-attribute decision-making problems that can be solved using the AHP framework. In the following section, we present an example in which we rank market center-order type pairs based on the execution quality of small orders of the Nasdaq 100 Trust Series I (QQQ).

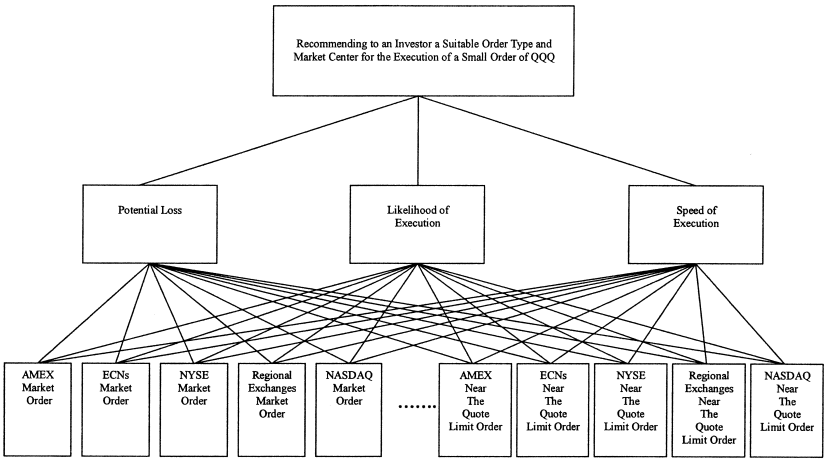

Fig. 1. The hierarchy for evaluating the execution quality of market centers.

4. An example: evaluating the execution quality of market centers for QQQ

The first step in the AHP is to represent a given decision problem in a hierarchical structure, which typically includes three levels: the overall objective of the decision, the assessment criteria, and the competing alternatives. Fig. 1 presents the hierarchy of evaluating the order execution quality in different market centers for a hypothetical investor. In this case, the overall objective is to recommend to an investor a suitable order type and market center for the execution of a small order of QQQ. The assessment criteria are the different component measures of order execution quality for the investor, and the 25 market center-order type pairs are the competing alternatives. The hierarchy in Fig. 1 is kept simple for illustration purposes, and can be easily modified to include additional assessment criteria and market centers.

We use QQQ in our example because it has been the most actively traded issue among all the stocks and exchange traded funds listed on the American Stock Exchange (AMEX) since its inception on March 10, 1999. Both small individual investors as well as institutional investors heavily trade QQQ because it provides significant portfolio diversification benefits. The other characteristic of QQQ that makes it a good example for our study is that it is traded on all five market centers that we focus on: the AMEX, the NYSE, Nasdaq, Electronic Communication Networks (ECNs), and regional exchanges.

We suggest potential loss to a dealer or a trader taking the other side of an order (from now on referred to as potential loss), likelihood of execution, and speed of execution as the evaluation criteria of order execution quality. Importance weight of each criterion may be different for each investor based on his or her preferences and constraints. Therefore, the investor must first determine the relative importance of the execution quality criteria through pairwise comparisons. Table 1 presents a pairwise comparison scale typically used in the AHP. A financial advisor can guide the investor in the process of pairwise comparisons through a questionnaire, which can be prepared for a specific order size. With three criteria, the investor has to make three pairwise comparisons. A sample questionnaire and responses

Table 1
Pairwise comparison scale

Level of importance	Definition	Explanation
1	Equal Importance	Two attributes contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one attribute over another
5	Essential or strong importance	Experience and judgment strongly favor one attribute over another
7	Very strong or demonstrated importance	An attribute is favored very strongly over another; its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one attribute over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between adjacent scale values	When compromise is needed

from a hypothetical investor are presented in the Appendix. Table 2 Panel A presents the preferences of the hypothetical investor in a matrix format. For example, comparing potential loss to speed of execution (row 1, column 3 of the matrix), the investor assigns a preference score of seven, indicating that he or she puts more emphasis on potential loss as an execution quality criterion. The investor also sees potential loss as more important compared to likelihood of execution, and assigns it a preference score of three.

It is possible that the investor's pairwise comparisons may contain inconsistencies. For example, suppose the investor ranks potential loss as more important than likelihood of execution. The investor also considers likelihood of execution more important than speed of execution. If the same investor then indicates that speed of execution is more important than potential loss, then this investor will have made three statements about preferences that are inconsistent with each other. We verify the consistency of the pairwise comparison matrix using an index developed by Saaty (1977, 1980). Then, we estimate the relative importance weights of the execution quality criteria using the following equation:

$$PW = \lambda_{\max} W \tag{1}$$

where P is the pairwise comparison matrix, $\lambda_{\max}$ is the largest eigenvalue of P, and W is the right eigenvector of P. For further discussion on the eigenvalue method of estimating relative

Table 2
Analysis of the execution quality criteria for the hypothetical investor

Execution quality criteria	Panel A: Investor's pairwise comparisons of execution quality criteria			Panel B: relative importance of execution quality criteria
	Potential loss	Likelihood of execution	Speed of execution	Relative importance weights
Potential Loss	1	3	7	0.6693
Likelihood of execution	1/3	1	3	0.2425
Speed of execution	1/7	1/3	1	0.0882

weights, we refer the reader to Saaty (1977, 1980). Table 2 Panel B presents the relative importance weights of the execution quality criteria as determined by the hypothetical investor. In this example, the investor sees potential loss as the most important criterion for measuring execution quality with a weight of 0.6693. This investor also considers likelihood of execution more important than speed of execution.

Rule 11Ac1-5 requires market centers to report their execution quality statistics for four size categories and five order types. Order size categories are 100–499 shares, 500-1999 shares, 2000–4999 shares, and 5000 shares or higher. Order types are market orders, marketable limit orders, inside-the-quote limit orders, at-the-quote limit orders, and near-the-quote limit orders.[1] We use these order types and the NYSE, the AMEX, Nasdaq, ECNs, and regional exchanges to form the market center-order type pairs. Regional exchanges in our sample are Chicago Stock Exchange, Boston Stock Exchange, Philadelphia Stock Exchange, and Cincinnati Stock Exchange. We include Bernad L. Madoff Investment Securities, Knight Securities, Salomon Smith Barney, and Trimark Securities in our sample of Nasdaq market makers. ECNs are Archipelago Exchange, Brut LLC, Island, and Instinet.[2] A list containing the codes and the titles of market centers as well as the codes and the titles of member firms is provided in Table 3.

We obtain the execution quality statistics of orders that are in the small size category (100–499 shares) for each market center for the month of October 2002 using the data mandated by Rule 11Ac1-5. Panels A and B of Table 4 include these statistics for market orders and marketable limit orders, respectively.[3] Table 5 shows field names for the execution quality statistics and their definitions. We use a weighted average based on the number of orders submitted to a member firm to calculate the composite execution quality statistics for the NYSE, the AMEX, and Nasdaq. We calculate a weighted average based on the number of orders submitted to each ECN to obtain the composite execution quality statistics for the ECNs. We use a similar approach for regional exchanges. For each regional exchange, we first calculate a weighted average based on the number of orders submitted to each member firm, then, we obtain a weighted average across all regional exchanges in our sample to compute the composite execution quality statistics of regional exchanges.

We compare the market center-order type pairs based on three execution quality criteria: potential loss, likelihood of execution, and speed of execution. We use realized spread (RSPR) as a proxy for potential loss. Under Rule 11Ac1-5, realized spread is defined as twice the difference between the execution price and the midpoint of the consolidated best bid and ask prices five minutes after the time of order execution for buy orders, and twice the difference between the midpoint and the execution price for sell orders. A positive realized spread indicates a price increase (decrease) five minutes after the execution of a sell (buy) order. Therefore, it reflects a potential loss for an individual trader and a potential profit for a dealer or a trader taking the other side of the order. The larger the positive realized spread, the worse off the individual trader is. When realized spread is negative, it implies that the other side of the trade is losing money.

We use fill rate (FR) to represent the likelihood of execution.[4] Fill rate is calculated using the following equation.

Table 3
The list of exchange codes, market centers, member firm codes, and member firm titles*

Exchange code (Part_id)	Market center	Member firm code (M_id)	Member firm
A	AMEX	AMEX	BARS (Booth Automated Routing System)
		A935	Susquehanna Investment G.
B	Boston	B003	Charles Schwab & Co., Inc.
		B004	D.A. Davidson & Co.
		B016	National Financial Services LLC (Fidelity)
		B017	Pershing Trading Company, LP
C	Cincinnati	CCINN	Cincinnati Stock Exchange
		CDEMC	Dempsey Trading Co.
		CSCOT	Scottrade, Inc.
N	NYSE	N0056	Slk Index Specialist
		N9999	ITS (Intermarket Trading System)
M	Chicago	M00833	Dempsey & Company LLC
		MITS	ITS (Intermarket Trading System)
P	Archipelago Exchange	PARCAX	Archipelago Exchange
T	Brut	TBRUT	Brut, LLC (ECN)
T	Instinet	TINET	Instinet (ECN)
T	Island	TISLD	Island (ECN)
T	Nasdaq	TMADF	Bernard L. Madoff Investment Securities
		TTRIM	Knight Securities
		TCAES	CAES Trading Sytem
X	Philadelphia	X0354	Joseph D. Heard JR Inc.
		X1354	Joseph D. Heard JR Inc. (ITS)

* For several reporting market centers such as AMEX, Boston Stock Exchange and Cincinnati Stock Exchange, the M_id data field contains more than one member firm. The reason is that market centers report all the statistics separately for their member firms. For example, on the Boston Stock Exchange, "B", there were four member firms that traded QQQ for the month of October 2002: Charles Schwab & Co., Inc., D.A. Davidson & Co., National Financial Services LLC, and Pershing Trading Company, LP.

$$\mathrm{FR} = \frac{\mathrm{Shrs\_ex}}{\mathrm{Shrs\_sub\text{-}Shrs\_can}} \tag{2}$$

where Shrs_ex is the number of shares executed by the receiving market, Shrs_sub is the number of shares submitted, and Shrs_can represents the number of shares canceled before execution.

All market centers use five speed categories to measure execution time as mandated by Rule 11Ac1-5: 0 to 9 seconds; 10 to 29 seconds; 30 to 59 seconds; 60 to 299 seconds; and 5 minutes to 30 minutes. We use time-weighted average of execution speed (ES) to represent the speed of execution:

$$\mathrm{ES} = \frac{(5 \times \mathrm{S}_{0\text{–}9}) + (20 \times \mathrm{S}_{10\text{–}29}) + \ldots + (1050 \times \mathrm{S}_{5\mathrm{M}\text{–}30\mathrm{M}})}{\mathrm{Shrs\_ex}}. \tag{3}$$

In this equation, weights are the midpoints of execution time in seconds for each category, and $\mathrm{S}_{(.)}$ represents the number of shares executed for the associated speed category.

Table 6 shows the values of RSPR, FR, and ES that we calculate for each market

Table 4
Panel A: Uniform execution quality statistics as mandated by Rule 11Ac1-5 Panel A: Uniform execution quality statistics for small *Market Orders* of QQQ for the month of October, 2002

Part_id	M_id	Ords_sub	Shrs_sub	Shrs_can	Shrs_ex	Shrs_rt	x_0_9	x_10_29	x_30_59	x_60_229	x_5m_30m
A	AMEX	25	4800	0	4800	0	4800	0	0	0	0
A	A935	15481	3255830	11300	3244730	0	1819685	1209965	199359	15521	200
P	PARCAX	1875	241661	2000	103061	136600	139329	75348	20424	4560	0
T	TINET	38	8631	0	2100	6531	5247	2843	541	0	0
N	N0056	3024	592177	1350	590727	100	539373	50337	1117	0	0
T	TMADF	4258	865590	0	863985	0	754540	87775	19379	2291	0
T	TTRIM	8187	1746761	4300	1741836	0	1715639	8147	7635	10415	0
B	B003	3157	692493	0	692693	0	599325	87367	5591	410	0
B	B004	23	4834	0	4834	0	3092	1252	300	190	0
B	B016	3660	820272	0	820272	0	699556	104275	14221	1220	1000
B	B017	3916	799603	0	799603	0	610089	142877	32909	13728	0
M	M00833	9458	2046715	6160	2039868		1826020	154993	43396	14759	400
X	X0354	5472	1171357	6240	1165117	0	664438	465105	31936	3638	0
C	CCINN	1747	377262	0	377262	0	290448	67527	10830	7757	700
C	CDEMC	1547	334947	0	334947	0	261683	58929	9430	4205	700
C	CSCOT	200	42315	0	42315	0	28765	8598	1400	3552	0

Part_id	M_id	R_spd	E_spd	N_PI	Amt_PI	Tim_PI	N_AQ	Tim_AQ	N_OQ	Amt_OQ	Tim_OQ
A	AMEX	0.0513	0.0108	0	0	0	4400	1.4	400	0.01	1
A	A935	0.0072	0.0126	787861	0.0171	14.5	967038	10.6	1489831	0.0173	11.9
P	PARCAX	−0.0027	0.0122	29150	0.014	8.3	130600	6.4	79911	0.0179	21.2
T	TINET	0.1024	0.061	2352	0.017	6.2	2739	9.5	3540	0.0788	11.3
N	N0056	0.0182	0.0292	62426	0.014	6	124128	6	404273	0.0206	6
T	TMADF	0.0032	0.0048	123378	0.0137	5.3	624621	2	115986	0.0125	10
T	TTRIM	0.0031	0.0104	670306	0.0103	0.5	1055445	0.2	16085	0.0256	50.7
B	B003	0.0156	0.0137	63977	0.0126	6	394885	3.6	233831	0.016	7.4
B	B004	0.0588	0.0168	322	0.01	13.6	3172	10.6	1340	0.0238	18.6
B	B016	0.0061	0.0066	94455	0.0142	12	605672	4.2	120145	0.0156	10.6
B	B017	0.0074	0.0061	108269	0.0138	11.5	563882	6.5	127452	0.0149	16.8
M	M00833	0.0003	0.0048	441875	0.0157	8.7	1296294	3.2	301699	0.0188	13.6
X	X0354	0.0167	0.0173	156764	0.0137	11	522796	4.1	485557	0.0179	
C	CCINN	0.0076	0.0111	24354	0.0149	35.9	275827	6.2	77081	0.0188	14.8
C	CDEMC	0.0081	0.0114	19926	0.0149	37.7	244935	5.9	70086	0.019	13.4
C	CSCOT	0.0041	0.0087	4428	0.0147	28	30892	9	6995	0.0174	29.3

Continued

Table 4 *Continued*
Panel B: Uniform execution quality statistics for small *Marketable Limit Orders* of QQQ for the month of October, 2002

Part_id	M_id	Ords_sub	Shrs_sub	Shrs_can	Shrs_ex	Shrs_rt	x_0_9	x_10_29	x_30_59	x_60_229	x_5m_30m
A	AMEX	5	1000	0	1000	0	1000	0	0	0	0
A	A935	8805	1746664	446493	1300171	200	657582	497159	114330	29150	1750
P	PARCAX	18872	2979680	925488	1594262	459200	1693591	224342	54474	61855	19200
T	TBRUT	83	16500	11000	3200	4100	4000	2400	700	200	0
T	TCAES	950	166500	0	159500	0	159500		0	0	0
T	TINET	86023	18520054	16305581	2201574	12299	2092174	85999	17100	12300	4900
T	TISLD	102932	26336393	18858070	7468503	0	7284075	123751	30863	21929	6315
N	N0056	14307	2465555	468353	1985602	5900	1738432	206281	35614	9700	1475
N	N9999	85	12900	5400	7500	0	5900	1600	0	0	0
T	TMADF	206	43871	400	43471	0	32270	10235	826	140	0
T	TTRIM	2826	821707	25600	795707	0	779899	5850	3714	5844	300
B	B003	607	140894	185	140509	0	113458	21373	2150	3413	115
B	B016	332	80967	0	80667	0	65980	11812	2450	125	300
B	B017	1833	477014	1605	474609	0	338701	97555	27439	9999	715
M	M00833	829	191652	11087	177680	0	111736	36278	14796	13320	950
M	MITS	714	115600	67100	48500	0	17200	29900	1400	0	0
X	X0354	475	115734	7717	107237	0	48259	42771	9577	5700	700
X	X1354	666	111300	76300	35000	0	9500	25500	0	0	0
C	CCINN	272	65439	0	65439	0	46296	14866	3782	495	0
C	CDEMC	266	64639	0	64639	0	45696	14666	3782	495	0
C	CSCOT	6	800	0	800	0	600	200	0	0	0

Part_id	M_id	R_spd	E_spd	N_PI	Amt_PI	Tim_PI	N_AQ	Tim_AQ	N_OQ	Amt_OQ	Tim_OQ
A	AMEX	0.15	0.006	400	0.01	1.8	600	0.7	0	0	0
A	A935	0.0021	0.003	267234	0.0163	14.3	737967	18.6	295170	0.0134	12.7
P	PARCAX	0.0022	0.0076	67156	0.0117	4.2	1553509	15.7	432797	0.0114	5.3
T	TBRUT	−0.0158	0.0015	600	0.015	16.5	5900	15.3	800	0.01	13.6
T	TCAES	−0.0285	−0.0038	38200	0.0192	0.4	103200	0.4	18100	0.0113	0.4
T	TINET	0.0713	0.0884	140000	0.007	0.3	649842	5.1	1424031	0.0649	14.4
T	TISLD	0.0127	0.0235	2022675	0.0056	0	1768923	5.9	3676905	0.0223	3
N	N0056	0.0062	0.0141	154165	0.0145	7	1004649	8	832688	0.0146	6
N	N9999	−0.0421	0.0041	500	0.01	7	6300	7	700	0.0157	6
T	TMADF	0.0155	0.0029	6601	0.0132	8.1	30955	4.3	5915	0.0114	7.7
T	TTRIM	−0.0161	0.0175	6104	0.0228	27	784949	1.1	4654	0.0183	50.3
B	B003	0.005	0.0084	8155	0.0129	6.3	101594	10.3	30760	0.0134	7.8
B	B016	0.0036	0.0041	8660	0.012	10.3	61878	8.5	10129	0.0125	10.1
B	B017	−0.0066	0.0017	37997	0.0131	15.9	409891	11.9	26721	0.0124	12.7
M	M00833	0.0134	0.0143	11090	0.0109	8.1	109587	25.7	57003	0.0164	36.9
M	MITS	0.0195	0.0052	400	0.01	13.3	43700	13.6	4400	0.015	15.4
X	X0354	0.0256	0.012	11089	0.0126	16.1	61942	26.3	34206	0.0144	0
X	X1354	0.0192	0.0069	200	0.01	0.1	31500	0.1	3300	0.0118	0
C	CCINN	−0.005	0.0055	6045	0.0136	16.6	51024	6.5	8370	0.0129	14.9
C	CDEMC	−0.006	0.0055	5945	0.0137	16.6	50324	6.6	8370	0.0129	14.9
C	CSCOT	0.0813	0.0025	100	0.01	19	700	4	0	0	0

Table 5
Data fields and explanations for Rule11Ac1-5 statistics

Data field	Field description
Part_id	Reporting participant exchange identifier
M_id	The code for the market center receiving the order
Ords_sub	Number of orders submitted
Shrs_sub	Number of shares submitted
Shrs_can	Number of shares canceled
Shrs_ex	Number of shares executed
Shrs_rt	Number of shares sent to and executed at an alternate market center
$S_{0\ 9}$	Number of shares executed between 0 and 9.9 seconds
$S_{10\ 29}$	Number of shares executed between 10 and 29.9 seconds
$S_{30\ 59}$	Number of shares executed between 30 and 59.9 seconds
$S_{60\ 229}$	Number of shares executed between 60 and 299.9 seconds
$S_{5m\ 30m}$	Number of shares executed between 5 and 30 minutes
R_spd	Realized Spread*
E_spd	Effective spread**†
N_PI	Number of shares receiving price improvement†
Amt_PI	Average amount of price improvement per share (in dollars), for all price improved shares†
Tim_PI	Average execution speed (in seconds) for all price improved shares†
N_AQ	Number of shares executed at the NBBO at the time of order entry†
Tim_AQ	Average execution speed (in seconds) for all shares executed at the NBBO†
N_OQ	Number of shares executed outside the NBBO†
Amt_OQ	Average amount executed away from the quote per share, for all shares executed outside the NBBO†
Tim_OQ	Average execution speed (in seconds) for all shares executed outside the NBBO†

* The difference between the execution price of an order and the midpoint of the NBBO (National best bid price and best offer price) as it stands five minutes after the time of order execution.

** The difference between the execution price of an order and the midpoint of the NBBO at the time of order receipt

† Only valid for market and marketable limit orders.

center-order-type pair. We find that realized spread is negative for inside-the-quote limit orders and near-the-quote limit orders in the AMEX, the NYSE, ECNs, and Nasdaq. Nasdaq also has a large negative realized spread (−0.0174) for marketable limit orders, which implies that market makers or other liquidity providers on Nasdaq lose money on average when they take the other side of marketable limit orders. When dealers have serious inventory imbalances that need to be adjusted in a short time, they demand liquidity and pay the spread rather than earning the spread. As is apparent in Table 6, the only market center that does not report negative realized spreads for any of the order types is regional exchanges. All other market centers have negative realized spreads for at least two types of orders. This indicates that it is difficult for dealers or specialists to make short-term profits by taking the other side of the small orders of QQQ.

We show that orders submitted to the NYSE, AMEX, Nasdaq, and regional exchanges are executed almost with the full-submitted size for all order types except near-the-quote limit orders. Because these limit orders are submitted outside the best bid price and best ask price, they might expire without execution as the prices move away from the submitted limit price. ECNs have very high fill rates that are close to one for all types of orders except market orders. ECNs' fill rate is only 0.4263 for market orders. The ECNs that we include in our

Table 6
Values of execution quality attributes for small orders of QQQ for each market center-order type pair for the month of October, 2002

Market centers	Proxies for execution quality criteria		
	Realized spread (RSPR) ($)	Fill rate (FR)	Time-weighted average of execution speed (ES) (seconds)
AMEX market orders	0.0073	1.0000	13.9382
ECNs market orders	−0.0006	0.4263	16.3748
NYSE market orders	0.0182	0.9998	6.3536
Regional exchanges market orders	0.0076	0.9999	10.4404
Nasdaq market orders	0.0031	0.9991	6.8370
AMEX marketable limit orders	0.0022	1.0000	19.5771
ECNs marketable limit orders	0.0360	0.9764	9.2420
NYSE marketable limit orders	0.0059	0.9942	8.8913
Regional exchanges marketable limit orders	0.0066	0.9964	18.0901
Nasdaq marketable limit orders	−0.0174	0.9995	7.1721
AMEX inside-the-quote limit orders	−0.0012	1.0000	22.2732
ECNs inside-the-quote limit orders	−0.0010	0.9991	6.8421
NYSE inside-the-quote limit orders	−0.0295	1.0000	7.8171
Regional exchanges inside-the-quote limit orders	0.0158	1.0000	24.1300
Nasdaq inside-the-quote limit orders	−0.0084	1.0000	35.2313
AMEX at-the-quote limit orders	−0.0018	1.0003	47.8369
ECNs at-the-quote limit orders	0.0000	0.9870	43.8894
NYSE at-the-quote limit orders	−0.0078	0.9937	11.9709
Regional exchanges at-the-quote limit orders	0.0149	0.9990	31.5522
Nasdaq at-the-quote limit orders	0.0039	0.9900	64.4674
AMEX near-the-quote limit orders	−0.0117	0.9995	174.1917
ECNs near-the-quote limit orders	−0.0056	0.9727	72.2757
NYSE near-the-quote limit orders	−0.0200	0.9837	61.3051
Regional exchanges near-the-quote limit orders	0.0094	0.9507	218.7546
Nasdaq near-the-quote limit orders	−0.0030	0.9208	315.7460

analysis route more than half of the market orders to other market centers. As a result, orders submitted to ECNs take the highest execution time among all the market centers with 16.3748 seconds for market orders. For each market center, marketable limit orders take more time to execute than market orders except ECNs. NYSE and Nasdaq have relatively low execution times of 6.3536 seconds and 6.8370 seconds for market orders, respectively. Regional exchanges and AMEX execute market orders at around 10.4404 seconds and 13.9382 seconds, respectively. At-the-quote limit orders and near-the-quote limit orders wait longer than other order types to be executed on each market center, since those orders will take their place behind the marketable limit orders and inside-the-quote limit orders on the limit order book.

After we calculate the values of RSPR, FR, and ES, we transform them so that they map onto the interval ranging from one to nine, where the minimum value and the maximum value are transformed to one and nine, respectively. The variables for which the decision-maker requires smaller values are transformed so that the maximum value corresponds to one and the minimum value corresponds to nine. Then, we normalize the transformed values to

Table 7
Relative strength weights of market center-order type pairs under each execution quality criterion based on small orders of QQQ for the month of October 2002

Market centers	Proxies for execution quality criteria		
	Realized spread (RSPR)	Fill rate (FR)	Time-weighted average of execution speed (ES)
AMEX market orders	0.0341	0.0421	0.0448
ECNs market orders	0.0414	0.0047	0.0444
NYSE market orders	0.0240	0.0421	0.0458
Regional exchanges market orders	0.0338	0.0421	0.0452
Nasdaq market orders	0.0379	0.0421	0.0457
AMEX marketable limit orders	0.0388	0.0421	0.0440
ECNs marketable limit orders	0.0076	0.0406	0.0454
NYSE marketable limit orders	0.0354	0.0417	0.0454
Regional exchanges marketable limit orders	0.0347	0.0419	0.0442
Nasdaq marketable limit orders	0.0570	0.0421	0.0457
AMEX inside-the-quote limit orders	0.0419	0.0421	0.0437
ECNs inside-the-quote limit orders	0.0418	0.0421	0.0457
NYSE inside-the-quote limit orders	0.0681	0.0421	0.0456
Regional exchanges inside-the-quote limit orders	0.0263	0.0421	0.0434
Nasdaq inside-the-quote limit orders	0.0487	0.0421	0.0420
AMEX at-the-quote limit orders	0.0425	0.0421	0.0403
ECNs at-the-quote limit orders	0.0408	0.0413	0.0408
NYSE at-the-quote limit orders	0.0480	0.0417	0.0450
Regional exchanges at-the-quote limit orders	0.0271	0.0421	0.0425
Nasdaq at-the-quote limit orders	0.0373	0.0415	0.0381
AMEX near-the-quote limit orders	0.0517	0.0421	0.0237
ECNs near-the-quote limit orders	0.0460	0.0403	0.0371
NYSE near-the-quote limit orders	0.0593	0.0411	0.0385
Regional exchanges near-the-quote limit orders	0.0322	0.0389	0.0178
Nasdaq near-the-quote limit orders	0.0436	0.0370	0.0051

calculate the relative strength weights of the market center-order type pairs in terms of the execution quality criteria. Similar normalization methods are used in studies that incorporate quantitative data to the AHP (see Weck et al., 1997; and Yu et al., 2000). Table 7 shows the relative strength weights for market center-order type pairs based on the values of the execution quality criteria. For example, given its realized spread value, NYSE-inside-the-quote limit order pair has the highest strength weight of 0.0681, indicating that an inside-the-quote limit order executed at the NYSE is the best choice for the investor under the potential loss criterion. After determining the relative importance of the execution quality criteria and the strength of the market center-order type pairs under each criterion, we combine them to determine the relative suitability of market center-order type pairs for executing a small order of QQQ for the hypothetical investor in our example. The relative strength weights of market center-order type pairs under the execution quality criteria form a 25×3 matrix. Each row of the matrix represents a market center-order type pair and each column represents a criterion. The relative importance weights of the execution quality criteria for the investor form a 3×1 vector. We multiply the relative strength matrix of the

Table 8
The relative suitability weights of market center-order type pairs for the execution of small market orders of QQQ for a hypothetical investor

Market center-order type pairs	Suitability weights	Suitability ranks
NYSE inside-the-quote limit orders	5.9814%	1
NYSE near-the-quote limit orders	5.3063%	2
Nasdaq marketable limit orders	5.2360%	3
AMEX near-the-quote limit orders	4.6878%	4
Nasdaq inside-the-quote limit orders	4.6483%	5
NYSE at-the-quote limit orders	4.6245%	6
ECNs near-the-quote limit orders	4.3838%	7
AMEX at-the-quote limit orders	4.2229%	8
ECNs inside-the-quote limit orders	4.2180%	9
AMEX inside-the-quote limit orders	4.2124%	10
ECNs at-the-quote limit orders	4.0946%	11
AMEX marketable limit orders	4.0085%	12
Nasdaq market order	3.9630%	13
Nasdaq near-the-quote limit orders	3.8599%	14
Nasdaq at-the-quote limit orders	3.8353%	15
NYSE marketable limit orders	3.7808%	16
Regional exchanges marketable limit orders	3.7306%	17
AMEX market orders	3.7001%	18
Regional exchanges market orders	3.6816%	19
ECNs market orders	3.2776%	20
Regional exchanges near-the-quote limit orders	3.2548%	21
Regional exchanges at-the-quote limit orders	3.2060%	22
Regional exchanges inside-the-quote limit orders	3.1632%	23
NYSE market order	3.0320%	24
ECNs marketable limit orders	1.8909%	25

market center-order type pairs by the relative importance vector of the execution quality criteria to obtain a 25×1 vector, which reflects the relative suitability of the market center-order type pairs for the investor. Table 8 shows the elements of this vector as well as the suitability rankings of the market center-order type pairs.

In our example, the most important criterion for the hypothetical investor, who submits a small order for QQQ, is potential loss, followed by likelihood of execution and speed of execution. The NYSE-inside-the-quote limit order pair ranks first based on these criteria with a suitability weight of 5.9814%. It is followed by the NYSE-near-the-quote limit order pair with a suitability weight of 5.3063%. For all order types, regional exchanges rank very low in the list. The reason for this is that potential loss, measured by realized spread, is positive and large for most of the order types on regional exchanges, indicating a large potential loss by the hypothetical investor. The rankings we obtain reflect the relative importance of each execution quality criterion for the hypothetical investor in our example.

5. Summary

In this paper, we used the AHP to develop a framework for evaluating market center-order type pairs based on a set of execution quality criteria. The AHP allows an investor to

incorporate his or her particular preferences and constraints into the comparison of execution quality in market centers. The main contributions of this paper are its introduction to the market microstructure literature of a methodology that is widely used in multi-attribute decision-making, and the development of a framework that allows investors to utilize the data available as a result of Rule 11Ac1-5.

Notes

1. In Rule 11Ac1-5, the terms inside-the-quote limit order, at-the-quote limit order, and near-the-quote limit order are described as non-marketable buy (sell) orders with limit prices that are, respectively, higher (lower) than, equal to, and lower (higher) by $0.10 or less than the consolidated best bid (offer) at the time of order receipt. A marketable limit order is any buy (sell) order with a limit price equal to or higher (lower) than the consolidated best offer (bid) at the time of order receipt.
2. In July 2000, the Pacific Stock Exchange signed an agreement with Archipelago, an ECN, to create the Archipelago Exchange. On October 25, 2001, the Pacific Exchange received approval from the SEC to launch the "Archipelago Exchange" enabling all buyers and sellers to meet electronically.
3. For brevity purposes, we only include market orders and marketable limit orders in Table 4.
4. Low fill rates could be desirable for a trader who would like a better ability to quickly cancel limit orders. If the decision hierarchy is set up by a trader that considers low fill rate as an advantage, then the questionnaire would include "ability to quickly cancel an order" as an evaluation criterion.

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Appendix: sample questionnaire

Note: responses from the hypothetical investor are in bold italic.

Use a scale of one through nine, where one indicates both criteria are equally important and nine indicates the one criterion is absolutely more important, to compare the relative importance of each execution quality criterion.

1. Which is more important: potential loss or likelihood of execution?

Potential loss

Specify the relative importance using the following scale.

1 2 ***3*** 4 5 6 7 8 9

2. Which is more important: potential loss or speed of execution?
Potential loss
Specify the relative importance using the following scale.
1 2 3 4 5 6 ***7*** 8 9
3. Which is more important: likelihood of execution or speed of execution?
Likelihood of execution
Specify the relative importance using the following scale.
1 2 ***3*** 4 5 6 7 8 9

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