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ABSTRACT

In the past decade traditional market structures have been drastically revolutionized, creating new potential for electronic trading. The driving forces are changes in trading behavior, advances in technology and new regulation. Traditional exchanges are challenged by new electronic trading platforms competing on the basis of price, cost, speed and efficiency. As trading has become more fragmented occurring in multiple venues the complexity for intelligent order routing decisions (smart order routing) will increase and extend the demand for sophisticated trading tools and efficient technology. Market fragmentation and dispersion of liquidity impose new challenges for investment firms to achieve best execution for their client orders. Against this background we examine two order execution strategies where one approach applies a pre-defined rule framework (static best execution); the alternative considers smart order routing decisions using real-time market data (dynamic best execution). We elaborate the benefits of smart order routing and outline our research approach for the validation of these findings.

Keywords

Best execution, MiFID, market fragmentation, smart order routing

INTRODUCTION

In recent years modern communication technology has dramatically changed the way financial assets are traded. With the emergence of new electronic trading platforms such as BATS, Chi-X, or Turquoise traditional exchanges are challenged by new market entrants. Examples for electronic trading platforms are Electronic Communication Networks (ECN), Crossing Networks (CN) and Multilateral Trading Facilities (MTF). Thus, equity trading has become more fragmented as an increasing number of venues are contesting for market shares and liquidity. Venues are considered to be the potential order execution platforms or trading systems that can be used for the best execution process. This trend seems to continue as more than another dozen new European cross-border venues are planned or already announced (FESE 2008). The key problem for the new competitors is to attract sufficient order flow to assure liquidity. Liquidity, i.e. the designated ability to trade, is an important objective of market quality and determines a market's attractiveness (Harris 2003). Investors also benefit from dispersed trading in terms of faster, anonymous and fully automated order executions at lower cost (Stoll 2005). But, diversity of trading venues increases complexity. In a changing environment investment firms (or their clients) need to decide which trading venues offer the most favorable conditions. Additional pressure arises from regulation. In November 2007, the Markets in Financial Instruments Directive (MiFID) entered into force with the clear objective to harmonize the European financial market's landscape. Classifying trading services into three categories i) regulated markets ii) multilateral trading facilities (MTF) and iii) Systematic Internalisers (SI), the MiFID regulation is the key enabler for the competition that can be observed at present. Moreover, MiFID promotes investor protection by introducing the rules of conduct applicable to investment service providers, including the best execution requirements. Investment firms must establish effective arrangements to achieve the most favorable results for their clients when executing orders (best execution), including a best execution policy that contains information on the different trading places offered for order execution and the criteria for the selection of the most suitable venues (Ferrarini 2007).

Against this background – increased number of trading choices and tight regulatory execution requirements – the allocation of client orders has become very challenging. Investment firms may obtain support from IT-based trading tools such as algorithmic trading and / or smart order routing systems. A very simple definition by Stoll (2005) describes smart order routing as a computer program that sends an order to the best market. This raises two questions. *How* should orders be routed and *where* is the best market for order execution?

The contribution of this paper is to compare two ways of executing client orders with an initial focus on the German equity market. On the one hand we present the static best execution approach as it has been implemented by most investment firms, on the other hand we introduce dynamic best execution approach based on smart order routing technology that incorporates real time market data into the order routing decision. Although the latter proposal exceeds the current regulatory requirement our preliminary findings suggest that dynamic order routing has the potential to generate value, in particular when financial assets are traded across multiple venues.

The remainder of this paper is organized as follows. Section 2 reviews previous literature on smart order routing and best execution. Section 3 presents the two approaches to achieve best execution. Section 4 compares both concepts and applies the benefits of smart order routing to a numerical example. A research approach for the evaluation of the preliminary findings is provided in section 5. Section 6 concludes with an outlook.

RELATED LITERATURE

Automation has driven the diffusion of algorithmic trading while regulation and associated market fragmentation has enhanced the need for smart order routing technology. The two applications are inherent to the trading process and can be regarded as complements to each other. Smart routing, program trading and rule-based trading are other accepted expressions in literature to describe the concept of algorithmic trading (Domowitz and Yegerman, 2005). Algorithmic trading primarily addresses trading strategies in terms of timing, i.e. *when* to execute an order (Kissel and Malamut, 2006) while smart order routing is rather dedicated to execution strategies in terms of dividing or slicing, i.e. *where* and *how* to route an order (Sofianos, 2007).

Academic literature on this topic is not very extensive. Issues surrounding smart order routing comprise of reports and descriptive studies and largely appear as consulting pieces (Giraud 2004, Tabb 2004). First academic insights are provided by Hendershott, Jones and Menkveld (2008) and Domowitz et al. (2005). Their studies analyze the impact of algorithmic trading on market quality, in particular with regard to the effect on market liquidity and execution costs. Recently, Foucault and Menkveld (2008) studied the rivalry between two trading venues (EuroSETS launched by LSE and NSC operated by Euronext) for Dutch equities. Their findings suggest that multiple venues can co-exist in one market even if different fees are charged. Moreover, competition for order flow in limit order markets enhances market liquidity and market fragmentation reduces trading costs if all market participants adopt smart order routing.

Several related academic studies examine issues of best execution (Bessembinder and Kaufmann, 1997; Blume and Goldstein, 1992) and implications of certain practices, such as payment for order flow and preferencing mainly with a focus on quoted and effective spreads (Battalio, 1997; Battalio, Greene and Jennings, 1998). Macey and O'Hara (1996) argue that additional dimensions other than price deserve attention, for example regulatory requirements that specify the investment firms' best execution obligations.

The following section presents two basic opportunities for investment firms to implement the MiFID best execution requirement.

TWO APPROACHES TO ACHIEVE BEST EXECUTION

MiFID promotes investor protection by introducing new rules of conduct including the best execution requirement. As Macey et al. (1996) note, best execution is a multi-dimensional concept covering trade price, commissions, timing, immediacy, anonymity as well as trade mechanisms. Although MiFID provides some guidance the challenges for investment firms arise when it comes to the practical implementation of the best execution requirement. The organizational and technical management of their trading activities, in particular the choice of appropriate trading venues, is an important issue for these institutions as regulation forces them to seek "best execution" for their client orders.

This section examines two issues in more detail. One aspect deals with the process of venue selection as the achievement of best execution depends on the number and quality of trading venues offered by the investment firm. The second aspect covers the execution strategy, i.e. the enforced mechanism for routing client orders to one or more venues. In the following two concepts of static and dynamic best execution are introduced. While static best execution refers to an order submission based on a pre-defined rule framework, dynamic order execution goes beyond the current regulatory requirements and incorporates real time market data into the routing decision.

Static best execution

In Europe, the new regime on best execution (MiFID) requires investment firms to establish a so-called best execution policy disclosing all relevant information to their clients about how the best possible result is achieved for incoming orders. Although broadly discussed in the financial community a clearly defined practice for the implementation of the best execution obligation has not emerged yet. However, the European regulator provides some guidance by defining a minimum level of legal requirements (Gomber, Pujol and Wranik, 2008).

For the evaluation of the different execution venues certain criteria, e.g. price, cost, speed, etc. have to be applied followed by a weighting according to the attributes client type (retail or professional), financial instrument (e.g. equity, fixed income, derivatives) and nature of the order (e.g. size, type). The different combinations of these aspects result in a pre-defined rule framework and determine the destination(s) of an order. Furthermore, investment firms have to inform their clients about all available execution venues, at least those promising to achieve best execution on a consistent basis.

Table 1 presents the result of such a venue assessment extracted from a recent study on best execution policies (Gomber et al., 2008). It illustrates how different asset classes of securities are linked to a particular execution venue based on the financial instrument's index membership, geographical or other aspects. However, most investment firms prefer an abstract and summarizing description, for example domestic execution venue. Although the investment firm's internal provisions acknowledge a ranking of different trading venues the final destination of an incoming order is not always recognizable for clients. For example, for orders in shares of Index A, the preferred execution venue is represented by venue A (followed by venue B), clients only receive rather intransparent information that such orders are routed to a domestic execution venue based on internal calculation. In some cases assumed order sizes (here: 7,000 Euro) are provided for the best execution calculation.

Asset class	**Security group**	**Security group**	**…**	**Security group**
Equity	Shares of Index A (e.g. DAX)	Shares of Index B (e.g. EUROSTOXX 50)	…	Other foreign shares with foreign quotation
Assumed order size	7,000 Euro	6,000 Euro	…	Not provided
Execution venue	Domestic execution venue based on internal calculation **internal ranking**: 1. Venue A 2. Venue B 3. …	Domestic execution venue based on internal calculation **internal ranking**: 1. Venue B 2. Venue A 3. …	…	Order routing with client instruction only
Fixed income	Loans from domestic issuers	Other loans		
…	**…**	**…**	**…**	**…**
Derivatives	Certificates	Rights issue		
…	…	…	…	…

Table 1. Sample static best execution policy

Dynamic best execution

The idea of dynamic best execution is to achieve better results by including historic and current market data into the process of venue selection at the time of order entry. Instead of executing client orders according to a pre-defined rule framework each order is treated in an individual manner. Unlike static approaches, smart order routing technology assures that retail client orders are sent to the market(s) displaying the best price by accessing liquidity across multiple venues. An efficient order routing decision requires the collection, analysis and real-time application of relevant information for each venue as input variables for the smart router's business logic, for example market model, execution speed, bindingness of quoted prices, and immediacy of order execution. This information is either provided by the rules and regulation handbook of each venue or results from the investment firm's experience gained from former trading activities. Some aspects remain constant over time (e.g. market model, bindingness) and represent static information stored in the smart router's database. Other conditions are variable and change frequently, for example price and costs. Current price quotations require access to real-time market data. This also applies to costs as venues may charge fees depending on the number of (partial) executions. However, seeking the best price is not always sufficient because it may be equal at different venues. Among those venues offering equal quotes, other competitive factors such as fees or commissions have to be examined before routing client orders accordingly.

Both static and dynamic data are considered for the assessment of each execution venue. Finally, for retail orders price and costs (total consideration) determine where to route an order, as recommended by MiFID regulation, i.e. a ranking of venues is established by the smart router.

Table 2 illustrates a potential result of such a comparison for different trading venues. In this example the adequacy of a particular venue for the intended use in a smart order routing system is dependent on the availability of current market data, bindingness of prices and immediacy of order execution. For different reasons two venues are excluded by the smart router. Venue A cannot be considered due to the lack of market access and venue C fails to provide binding quotes.

Venue	Market model	Reference market	Market data	Bindingness	Immediacy	Market access
A	Hybrid book	Yes	Real-time	Yes, quote	Yes	No
B	Quality trading	Yes	Real-time	Yes, quote	Yes	Yes
C	Single auction	Yes	Variable	No, indication	No	Yes
D	Continuous trading	Yes	Real-time	Yes, quote	Yes	Yes
E	Open order book	No	Real-time	Yes, quote	Yes	Yes

Table 2. Venue characteristics for dynamic best execution

In consequence, venues B, C and E remain available for smart order routing. Although all three venues fulfill the prerequisites the preferred routing decision depends on the nature of the order (size and type) and the current market conditions.

The following section highlights the role of smart order routing technology along the trading process focusing on the search for the most appropriate venue (best market) and different options of order execution.

BENEFITS OF SMART ORDER ROUTING

For the implementation of a smart order routing it is helpful to understand the characteristics of the trading process. Following Stoll (2001) it can be divided into four components – information, order routing, execution and clearing & settlement. Markets provide *information* about past prices and current quotes that are disseminated across different vendors in real-time. In addition, some mechanism for *routing* orders is required before *execution* can occur. Finally, the provision of *clearing and settlement* concludes a typical trading process. In the following, this paper examines the interface between *order routing* and *execution* in more detail.

The trading process is typically triggered by an order entry. Before smart order routing functionality becomes effective orders pass through several processes, for example order validation and enrichment. Static data (e.g. ISIN) is added, the existence of client instructions and additional order attributes such as order type (e.g. market, limit order), transaction type (buy or sell), index membership of the financial instrument (e.g. DJ Industrial, DAX) and client category (e.g. retail or professional client) are checked before the order is routed to the appropriate venue.

With the completion of the order specific assessment the smart order routing mechanism is triggered. Figure 1 illustrates three different execution options along a simplified trading process.

First, orders may be completely filled at one single venue offering the best possible result (option 1) or the trade is incomplete, for example when a large order exceeds the consolidated liquidity across multiple markets (option 3). In latter case the routing process is repeated until the transaction is completed or cancelled depending on the client's instructions.

In some circumstances orders cannot be fully executed at the venue offering the best price (option 1), for example when the order exceeds the guaranteed order size of that particular venue. Such a case requires a two-way analysis. One direction examines whether a complete order execution is possible elsewhere either through a single or many partial executions. A complete execution can either be achieved by routing the order to one single venue that offers a good but not the best result (option 2a) or by splitting the order across multiple venues (option 2b). The decision to choose one single or rather multiple venues depends on the comparison of price and costs associated with the transaction. Finally, option 2c applies to orders that can only be executed by splitting, i.e. none of the specified trading venues offers a guaranteed order size to completely fill the order. In such a case the best price-cost combination determines to which venues the portions of the order are routed.

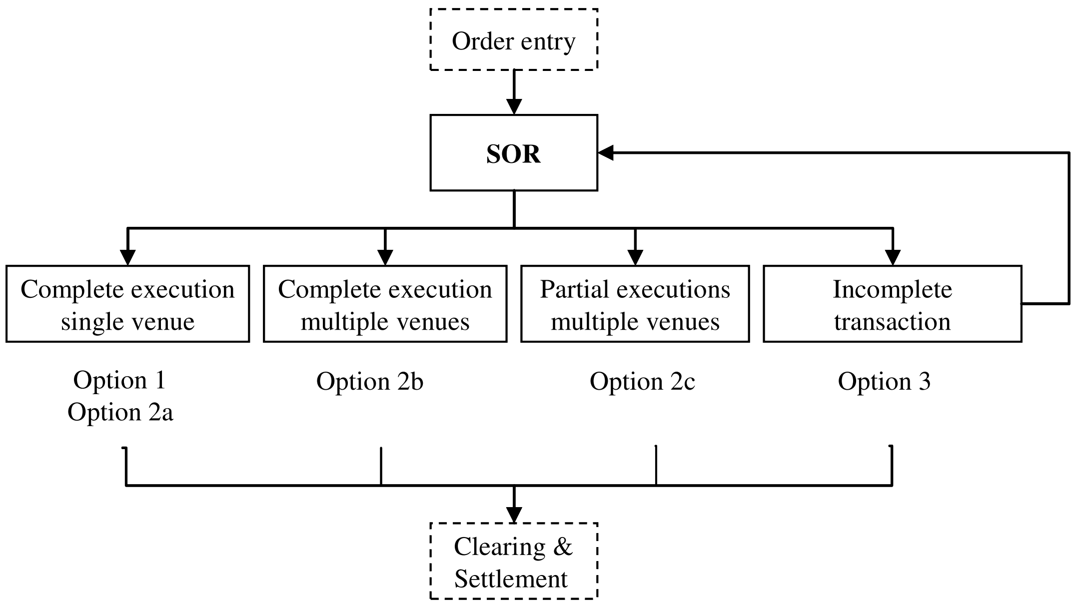

Figure 1. Trading process and execution options

In the following section we compare the results of static and dynamic best execution by means of a numerical example.

Numerical example

For this comparison, we deploy the following assumptions:

- We consider a retail client that wishes to sell n shares (with n varying throughout the example) of stock S (with S being member of stock index T) by placing a market order without instructing a particular execution venue.
- S is traded in multiple markets (venues A, B, C, D, E); venues A and C are excluded due to the lack of market access.
- Static best execution: All stocks of index T are routed to venue E.
- Dynamic best execution: Venues A and C are excluded and venues B, D and E remain available for smart order routing.

Table 3 summarizes the results for all options. The column *real-time data* indicates whether the price information originates from a quote or from calculating the Volume Weighted Average Price (VWAP) based on open order book data. *Costs* are directly derived from the rule and regulation handbook of the respective trading venue.

Venue	Real-time data	Rank	Volume	Price	Order size	Cost per share	Total (price + cost)	Result per share	Guaranteed order size
Option 1			200						
D	Quote	1	200	25.50	5,100	0.0204	**5,095.02**	25.4796	7,650
B	Quote	2	200	25.00	5,000	0.0095	4,998.10	24.9905	10,000
E	VWAP	3	200	24.50	4,950	0.0054	4,898.93	24.4946	4,950
Option 2a			400						
B	Quote	1	400	25.00	10,000	0.0295	**9,988.20**	24.9705	10,000
E	VWAP	2	400	24.13	9,650	0.0029	9,648.86	24.1221	9,650
(D)*	Quote		**300**	25.50	7,650	0.0204	7,643.88	25.4796	7,650
Option 2b			400						
D	Quote	1	**300**	25.50	7,650	0.0204	7,643.88	25.4796	7,650
B	Quote	2	**100**	25.00	2,500	0.0130	2,498.70	24.0870	10,000
		Total	400	25.375	10,150	0.0186	**10,142.58**	25.3564	17,650
(E)*	VWAP	2	400	24.13	9,650	0.0029	9,648.86	24.1221	9,650
Option 2c			600						
D	Quote	1	**300**	25.50	7,650	0.0204	7,643.88	25.4796	7,650
B	Quote	2	**300**	25.00	7,500	0.0295	7,491.50	24.9705	10,000
		Total	600	25.25	15,150	0.0250	**15,135.38**	25.2250	17,650
(E)*	VWAP	3	500	23.41	11,705	0.0024	11,703.82	23.4076	11,705
Option 3			1500						
D	Quote	1	**300**	25.50	7,650	0.0204	7,643.88	25.4796	7,650
B	Quote	2	**400**	25.00	10,000	0.0295	9,988.20	24.9705	10,000
E	VWAP	3	**500**	23.41	11,705	0.0024	11,703.82	23.4076	11,705
			1.200	24.46	29,355	0.0159	29,235.90	24.4441	29,355
* Venue excluded									

Table 3. Best execution for different order sizes

Option 1:

The sell order of 200 shares could be fully executed in all three venues. However, venue D provides the best overall result in terms of total consideration (price and cost) although involved with higher transaction costs compared to venues B and E. While the static approach routes any order in that particular financial instrument to venue E, the alternative decision based on a smart order routing mechanism achieves a surplus of 196.09 (5,095.02 – 4,898.93) for the investor. A less favorable execution at venue E represents a trade-through that occurs when an order is executed at a price inferior to the best price offered by an alternative market (venue D).

Option 2a and 2b

Assuming now a sell order of 400 shares, ceteris paribus, the guaranteed order size of venue D is exceeded and thus it is excluded as a potential trading venue. The smart order routing process continues to search for at least another venue allowing for a complete execution of the order. Two venues fulfill this condition but venue B offers better execution than venue E leaving the investor with an additional profit of 339.34 (9,988.20 – 9,648.86). Simultaneously the smart order routing process analyses different combinations of order splitting to complete the transaction. In this example, two partial executions at venue D (300 shares) and at venue B (100 shares) achieve the best possible result with a total return of 10,142.58.

Therefore, in this case order splitting is the preferred choice instead of placing the order at one single value. Matched against the static approach the investor's profit increases and sums up to 493.72 (10,142.58 - 9,648.86).

Option 2c

Increasing the sell order to 600 shares, ceteris paribus, alters the current conditions in a way that a complete order execution at one single venue cannot be realized, i.e. order splitting is unavoidable. In our example, the best result is achieved by equally distributing fractional amounts to the venues D (300 shares) and B (300 shares).

Option 3

Finally, we consider a sell order of 1,500 shares. The order exceeds the sum of all guaranteed order sizes offered across all relevant venues, i.e. the provided liquidity is insufficient to fully execute the order. In our example, 1,200 shares are sold at an average price of 24.46. After the order is split into three fractions (300 shares for venue D, 400 shares for venue B and 500 shares for venue E) and routed accordingly, 300 shares remain unfilled. The smart order routing process is repeated seeking for the venue(s) providing the most favorable conditions for the execution of the residual number of shares or cancelled depending on the client's instructions.

These observations partially ascribe to the flexible concept of best execution defined by MiFID. Although order execution should be assessed also on the basis of criteria other than price taking into account the nature of the client, the type of order and the characteristics of the financial instrument, there is no obligation for investment firms to connect to a particular execution venue. MiFID allows investment firms to include between one and n venues in their best execution policy provided that the selected venues promise to achieve the most favorable result for clients on a consistent basis. The best execution obligation though is satisfied when client orders have been executed according to the best execution policy, even if a better result could have been achieved at another trading venue not included in the policy.

As this numerical example demonstrates dynamic routing strategies seem to achieve better results than pre-defined rule frameworks (static best execution). Recent empirical evidence supports this view and encourages further research in this direction. Ende, Gomber and Lutat (2008) assess the economic relevance for smart order routing technology revealing a statistically significant extent of suboptimal order executions for assets traded in multiple markets. One could assume a wide-spread adoption of smart order routing technology but previous research contrasts the opposite. For the German market, Gomber et al. (2008) analyzed the implementation of the best execution requirement among the 100 largest banks and online brokers, finding that only one investment firms maintains a dynamic best execution policy that applies smart order routing technology. The majority of investment firms prefer to route their orders to domestic trading venues based on a static approach, alternative trading platforms such as the new MTFs BATS, Chi-X and Turquoise are not offered (yet).

FUTURE RESEARCH

Based on these previous results and the continuously changing environment of trading opportunities and services we intend to expand our research and validate both approaches presented with empirical data. For this purpose, we will use data of past order executions (completed trades) that could be provided by cooperating investment firms or market data vendors. The data set requires certain information, e.g. best bid/ask, trade price, trade direction, volume, date and time stamps should be available for a certain period of trading days in order to generate a sufficient number of trades. For the evaluation of both approaches the data also has to reveal whether a particular order execution resulted from a static or from a dynamic order routing decision.

Initially, the scope will be narrowed to the German equity market as Germany represents one of Europe's most important economies with a traditionally high level of market fragmentation. All eight German execution venues will be included in the analysis provided that all relevant aspects for dynamic order routing are fulfilled. Starting with the most liquid stocks (DAX30) the sample size will be broadened continuously covering additional indices (e.g. MDAX, TECDAX). Depending on the available data further adjustments of the sample will be considered.

Assuming that all investment firms make their best effort in achieving the most favorable result for their clients as prescribed by regulation one should expect that the difference in order executions based on a static or a dynamic routing decision will not reach a significant level, i.e. regardless of which approach is used equal results of order executions should be accomplished. However, sub-optimal order executions may occur, if better conditions are offered by a particular trading venue other than previously identified by the smart router or the pre-defined rule framework. According to Schwartz and Francioni (2004) sub-optimal order executions are defined as trade-throughs “when a transaction occurs at a price that is higher than the best posted offer or lower than the best posted bid and orders at these better prices are not included in the transaction”.

In order to determine to which extent the MiFID best execution requirement is fulfilled two groups of past order executions (completed trades) will be distinguished. While one group (A) will represent orders originating form users of smart order routing technology, the other group (B) will reflect orders from supporters of the static best execution approach. In the initial set up group A will consist of order executions from one investment firm that will serve as a benchmark for best execution. The order executions of group B will be divided into subcategories according to specific characteristics obtained from previous research on best execution policies (Gomber et al., 2008). These subcategories comprise of investment firms with similar or even identical best execution policies, i.e. orders are routed identically. Therefore one type of policy could represent one or more investment firms.

Against this background we hypothesize that there will be no significant level of differences in order executions based on the selected routing mechanism. For testing this hypothesis we consider using two variables, savings and relative price improvement (Ende et al., 2008). While savings is defined as the maximum saving per trade if executed in another trading venue, relative price improvement occurs when an investor pays less or receives more on a securities transaction than the bid and ask prices being currently quoted. Both variables will equal zero if the order was executed at the most favorable conditions. The results will need to be checked with appropriate statistical tests as the number of observed order executions may strongly vary for different stocks and trading venues.

However, we also consider enhancing the current approach in order to investigate the causes for the limited utilization of smart order routing technology so far. Hall and Khan (2003) argue that the contribution of new technology to economic growth requires that it is widely diffused and used. Thus, the decision whether to adopt smart order routing is influenced by many other factors, e.g. uncertain benefits, costs and other constraints. An accompanying survey among investment firms could generate additional insights that may enrich the current research set up.

CONCLUSION

This paper represents research in progress and attempts to provide a framework in order to compare the investment firm’s interpretations of the MiFID best execution requirement by introducing two concepts of static and dynamic best execution. Prior work largely focused on execution quality and corresponding measurements among and between different markets rather than on the investment firm’s individual perspective.

We intend to evaluate both concepts through further empirical research in order to answer the question to what extent each approach is capable to fulfill the best execution requirement under the new MiFID regime. The completed research will allow practioners to optimize the investment firm’s execution strategy by including a flexible decision mechanism of where and how to route orders depending on the current market situation. For regulators and academics, the study will contribute to existing research in market microstructure literature providing empirical evidence towards a superior achievement of best execution through smart order routing technology.

However, our research is also limited. First, generalization is difficult as empirical evidence is based on a very specific comparison of completed trades from one single investment firm using smart order routing technology with a sample of other investment firms deploying static approaches. Thus, potential performance variations between different smart routers are not captured in this study. Second, very few academic papers address smart order routing technology directly. Based on an expandable theoretical framework our analysis may miss important dimensions that influence the proposed set-up. Finally, investments involved with the implementation of smart order routing technology and / or with the establishment of access to (new) trading venues are left unattended and may outweigh the associated advantages.

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REFERENCES

1. Battalio, R. (1997) Third market broker-dealers: cost competitors or cream skimmers? *Journal of Finance,* 52, 341-352.
2. Battalio, R., Greene, J. and Jennings, R. (1998) Order flow distribution, bid-ask spreads, and liquidity cost: Merrill Lynch's decision to cease routinely routing orders to regional stock exchanges, *Journal of Financial Intermediation,* 7, 338-358.
3. Battalio, R., Hatch, B. and Jennings, R. (2004) Towards a National Market System for U.S. Exchange-listed Equity Options, *Journal of Finance,* 59, 933-962.
4. Bessembinder, H. and Kaufmann, H. (1997), A cross-exchange comparison of execution costs and information flows for NYSE-listed stocks, *Journal of Financial Economics*, 46, 293-319.
5. Blume, M. and Goldstein, M. (1992), Displayed and Effective Spreads by Market, *working paper*, University of Pennsylvania Wharton School.
6. Domowitz, I. and Yegerman, H. (2005) The Cost of Algorithmic Trading: A First Look at Comparative Performance, edited by Brian R. Bruce, *Algorithmic Trading: Precision, Control, Execution*, Institutional Investor.
7. Ende, B., Gomber, P. and Lutat, M. (2008) Smart Order Routing technology in the new European equity trading landscape, *Working paper,* Chair of E-Finance, University of Frankfurt
8. Ferrarini, G. (2007) Best execution and competition between trading venues – MiFID's likely impact, *Capital Markets Lay Journal,* 2, 4, 404-413.
9. FESE (2008) Federation of European Stock exchanges, Speech R. Plata, The post-MiFID landscape, Warsaw, (accessed 02/10/2009).
10. Foucault, T. and Menkveld, A.J. (2008) Competition for Order Flow and Smart Order Routing Systems, *Journal of Finance*, 63, 119-158.
11. Giraud, J. Best Execution for Buy-Side Firms: A Challenging Issue, A Promising Debate, A Regulatory Challenge, *consulting report*, Edhec-Risk Advisory.
12. Gomber, P., Pujol, G. and Wranik A. (2008) The Implementation of European Best Execution Obligation – An Analysis for the German market, *4th International Workshop on Enterprise Applications and Services in the Finance Industry (FinanceCom 2008),* Paris, France.
13. Hall, B. and Khan, B. (2003) Adoption of new technology, *UC Berkeley working papers NO. E03-330*, University of California Berkeley, Department of Economics.
14. Harris (2003) Trading and Exchanges: Market Microstructures for Practitioners, Oxford University Press.
15. Hendershott, T., Jones, C. and Menkveld, A. (2008) Does Algorithmic Trading Improve Liquidity? *working paper,* Columbia University.
16. Kissell, R. and Malamut R. (2006) Algorithmic decision-making framework, *Journal of Trading*, 1, 12–21.
17. Macey, J. and O'Hara, M. (1996) The Law and Economics of Best Execution, *Journal of Financial Intermediation*, 6, 3, 188-223.
18. Schwartz, R. A. and Francioni, R. (2004). Equity markets in action: The fundamentals of liquidity, market structure and trading. John Wiley& Sons, Inc., Hoboken, New Jersey.
19. Sofianos, G. (2007) Dark pools and algorithmic trading. *Algorithmic Trading: A Buy-Side Handbook* (2nd edition).
20. Stoll H. R. (2005) Electronic Trading in Stock Markets, *Working paper 05-04.*
21. Stoll, H. R. (2001) Market microstructure, *Working paper 01-16*, Financial Markets Research Center, Vanderbilt University.
22. Tabb, L. Institutional Equity Trading in America: A Buy-Side Perspective, *consulting report,* The Tabb Group.