# Smart Order Routing Technology in the New European Equity Trading Landscape

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**Abstract.** In Europe, fragmentation of execution venues has been triggered by increasing competition among markets and a new regulatory environment set up by MiFID. Against this background, IT-based sophisticated order routing systems (Smart Order Routing systems) promise to assure efficiency despite fragmented markets. This raises the question on the relevance and economic value of this technology in European equity trading. Based on order book data for EURO STOXX 50 securities of ten European electronic execution venues, this paper assesses the potential of Smart Order Routing technology by measuring the performance of actual executions in European order book trading relative to a Smart Order Router implementation that detects and accesses best European prices. We identify 6.71% full trade troughs and 6.45% partial trade-throughs in our dataset enabling for significant absolute and relative savings. This indicates that Smart Order Routing technology can provide business value by improving order executions in European cross-tradable equities.

**Keywords:** e-Finance, Auction, Economics of IS, Empirical Study, Marketplaces.

## 1 Introduction

In the last two decades, securities markets have undergone massive technological changes, mostly notable by the shift from floor trading to electronic trading systems [1, 2]. The electronification of market venues in Europe, i.e. exchange trading systems like Xetra (Deutsche Börse), SETS (London Stock Exchange) or NSC (Euronext France) took place in the late 1990s and enabled market participants (banks, brokers as well as their institutional and retail customers) to access electronic order books via remote access without the need for physical presence on an exchange floor.

Concerning the order execution by investors and brokers, i.e. the users of the markets, currently another massive technological change can be observed: In the past, orders were delegated to (human) brokers whose core competency is the execution of the investors' order flow. New trading technologies expand the decision set for organisations which seek for more trading control in order to reduce their implicit trading costs. Institutional investors and investment firms can choose to execute their orders via new electronic execution concepts like Direct Market Access, Algorithmic Trading and Smart Order Routing, at exchanges or alternative trading systems (e.g. crossing networks).

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The technological basis for this development is laid by the broker's business model of a virtual Direct Market Access. With this service orders are not touched by brokers anymore but are instead forwarded directly to markets. Algorithmic Trading and Smart Order Routing are built on the basis of Direct Market Access: Algorithmic Trading is based on mathematical models exploiting historical and real-time market data to determine ex ante or continuously the optimum size of the (next) order slice and its time of submission to the market [3]. Smart Order Routers perform an automated search for trading opportunities across multiple markets and route suborders to the most appropriate combination of markets as depicted in Figure 1.

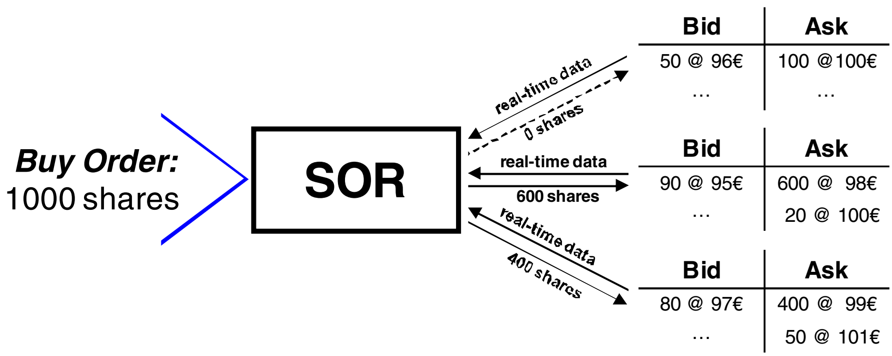


**Fig. 1.** Operating principle of a Smart Order Router (SOR)

While order execution strategies for securities that are listed exclusively at one stock exchange require only to focus on order timing and order slicing to minimise market impact things are more complicated when one or multiple alternative execution venues prevail. In such fragmented markets, a real-time investigation of order execution venues as well as their available executable orders and quotes can improve execution results and increase portfolio performance for both agent and proprietary trading. In the US, market fragmentation between regulated exchanges and Electronic Communication Networks introduced in the late '90s triggered the need for order routing concepts to assure best execution of orders. In European equity trading, market fragmentation is currently triggered by the emergence of new execution venues like BATS, Chi-X, Turquoise or Equiduct and their relevant market share gains in European blue chip stocks.[1] They are able to provide trading services across Europe based on the Markets in Financial Instruments Directive (MiFID) which has been in effect since November 1st, 2007. While institutional investors benefit from the increasing competition among venues in terms of lowered explicit costs or reduced latency, liquidity fragmentation requires sophisticated technology to achieve an order's completion at the most favourable prices. As MiFID requires investment firms to execute customer orders on terms most favourable to the client (best execution) both discussions within the MiFID regulatory process [4] as well as recent

[1] European market fragmentation (in terms of market share) is measured e.g. by Fidessa. For further information, please refer to http://fragmentation.fidessa.com.

competitive forces [5] raise the question on the relevance of IT-based Smart Order Routing systems for European equity trading.

Generally, for IT investments the question arises if these generate a positive business value [6]. Against this background our paper aims at investigating whether Smart Order Routing technology allows generating business value and thus, the related research question can be formulated as:

> *Does Smart Order Routing Technology enable for relevant improvements in order execution and thereby generate positive business value in European equity markets?*

For this purpose, we analyse the existence of suboptimal order executions in ten European securities markets. To simulate a Smart Order Router, for each of more than 8 million trades in European blue chip stocks, we seek better execution conditions, i.e. lower best offers for buy and higher best bids for sell orders. A relevant proportion of suboptimal order executions indicates the relevance and positive economic value of Smart Order Routing technologies and therefore justifies investments into their development.

The remainder of the paper is organised as follows: Section 2 reviews previous literature on Smart Order Routing and on order execution quality. Section 3 elaborates on our instrument and marketplace choice, describes the dataset and explains the assumptions and data adaptations necessary for the analysis. Section 4 presents and discusses our results. A conclusion and an outlook are provided in section 5.

## 2 Related Literature

Academic work on Smart Order Routing technology and its economic assessment is mainly related to execution quality measurement as well as relative execution performance of concrete trading venues:

With a few exceptions, studies investigating order execution quality across multiple trading venues are related to NYSE trading and brokers routing orders away from that venue for reasons of internalisation, internal crossing or order preferencing. Huang and Stoll [7] measure execution costs for a matched sample of NYSE and Nasdaq stocks and find execution costs for Nasdaq twice the NYSE costs. They conclude that internalisation and preferencing are obstacles for narrower spreads. Bessembinder and Kaufman [8] in a matched pairs study reach similar results with trading costs on the Nasdaq having fallen, but still being substantially higher than on the NYSE. Petersen and Fialkowski [9] find significant differences in midpoint trades between Nasdaq and NYSE and back these results with statistics of 19 percent of all retail brokerage orders in their sample routed to an exchange with an inferior quote. More recent studies on the subject include Battalio et al. [10] who compare NYSE execution prices with those of four regional exchanges and the Nasdaq InterMarket. Consistent with other research they find that overall, NYSE provides the best execution prices but lacks on execution speed. Bacidore et al. [11] point out that previous measures of execution quality might be biased for markets with substantial non-displayed liquidity.

Bakos et al. [12] analysed the law of one price against the background of brokers' execution performance and their different levels of commissions. They found relatively few price improvements, which are a measure of execution quality. The difference among brokers in obtaining price improvements was not statistically significant, but brokers do exhibit statistically significant differences in total trading costs as the rates of price improvement in general do not offset higher commissions charge. As the quality of order executions can vary heavily for different trading venues [13] a reasonable selection of a venue for a particular order appears to be important for the US and findings from Battalio et al. [14] indicate that strategic routing of decisions for orders, e.g. via Smart Order Routing, could help to improve overall order execution quality.

Against the background of new opportunities in order handling Ramistella [15] observed that the demand for reasonable order routing solutions has intensified for investment firms. Foucault and Menkveld [16] analyse the implications of market fragmentation and the rate of price priority violations (i.e. an order was executed in a market providing an inferior price compared to a price available in a different market) of two trading venues for Dutch equities. From their findings they interpret trade-throughs as being due to a lack of automation of routing decisions.

The contribution of this paper to the existent literature is twofold: First, it examines suboptimal order executions in Europe rather than the US and is based on order book data rather than price data. Second, to the knowledge of the authors it is the first paper that analyses execution performance after the MiFID introduction in Europe and assesses the relevance of Smart Order Routing technology in the new European landscape.

## 3 Methodology, Data and Assumptions

Before we will present our results in section 4, in the following we define important terms for our investigation of suboptimal order executions. Their existence delivers the economic foundation for the application of Smart Order Routing technologies in European equity trading. In this section we introduce the term "trade-throughs", describe the dataset and the data handling/cleaning operations as well as our hypotheses.

To identify suboptimal order executions, in the following we use the definition of trade-throughs according to Schwartz and Francioni [17] stated below.

**Definition: Trade-Through**
*A trade-through in a particular stock is said to take place "…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".*

Figure 2 shows an example of a trade-through where – although market A shows a best offer of 86.44 € – the buy order is executed on market B at 86.50 € per share.

Moreover, we label a situation where an order could be executed in a different market with its full order size at a better price (better bid or better offer limit) to be a *full trade-through*, whereas a situation in which only a part of an order could be executed in a different market at a better price (better bid or better offer limit) is classified as a *partial trade-through.*

In this paper we focus on the gross perspective, i.e. exclude (explicit) transaction costs that will be incorporated in a next step of the research project.

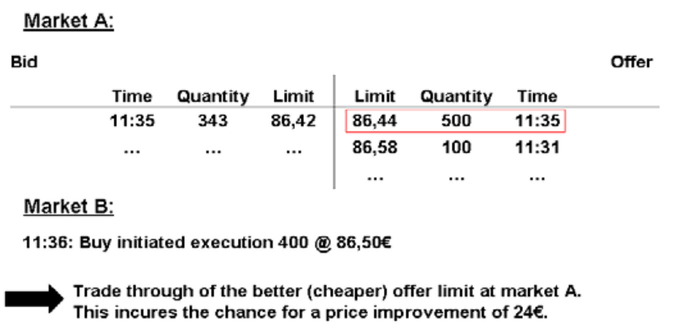


**Fig. 2.** Example of a trade-through situation

Smart Order Routing technology is intended to avoid trade-throughs as defined above since it allows to automatically detect fragmented liquidity across multiple markets. They continuously gather real-time data from the respective venues concerning their order book situations, i.e. current quoted volumes and prices. Based on this information the routing engine slices incoming orders and decides where to route individual suborders in respect of the best prices available in that logical second. Then, the routing engine receives order confirmations or notes of unfilled orders. In the latter case, the routing process will be repeated or cancelled depending on a customer's instructions.

As our objective is to determine the business value of Smart Order Routing technology we identify full and partial trade-throughs for each order execution in our data set. We compare trade data (trade price and volume, trade direction and time stamp) of the market where the execution actually took place (e.g. market B in figure 2) with the order book situations in all other markets simultaneously at the time of this execution. A trade-through (full or partial) is found if at least one marketplace exists (e.g. market A in figure 2) where a strictly positive amount of savings could be realised. We pick the market with the highest potential overall savings for the trade. Obviously, execution quality can be characterized by a multiple of other determinants like e.g. fill rates, execution likelihood and execution speed, but in the following we will focus only on price difference among trading venues.

## 3.1 Hypothesis and Statistical Testing

The new competition among trading venues triggered by MiFID raises the question on the business value of Smart Order Routing. Assuming traders' rational behaviour in executing their orders and based on their responsibility to identify the best result for clients' orders, one should expect that the proportion of sub-optimally executed orders will not reach a significant level. For testing this hypothesis two variables have been derived for each stock and each marketplace:

1. Absolute amount of savings (Savings), defined as the maximum savings per trade if executed in a different market. This variable equals zero if an order was executed optimally (placed at best market conditions), but is strictly positive if there is a market offering better execution conditions.

2. Relative price improvements (PI), defined as

$$PI = N_{adjust} \cdot \left| \frac{P_{better} - P_{trade}}{P_{trade}} \right|$$

$$with\ N_{adjust} = \begin{cases} \frac{N_{better}}{N_{trade}} & , if\ N_{better} < N_{trade} \\ 1 & , else \end{cases}$$

where $N_{better}$ equals the quoted number of shares in the market offering a better price and $N_{trade}$ is the actual trade's number of shares. $P_{better}$ and $P_{trade}$ are the potential price in the market offering better conditions and the actual trade price respectively. The *PI* variable equals zero if a trade was executed at best conditions and indicates the available relative improvement otherwise. $N_{adjust} = 1$ reflects full trade-throughs, whereas $N_{adjust} < 1$ reflects partial trade-throughs.

Assuming that both test statistics have a *Student's t distribution* under the null hypothesis both variables' means will be tested for

$$\mathbf{H_0}: \text{mean} = 0 \quad \text{against} \quad \mathbf{H_a}: \text{mean} > 0.$$

Results will be checked against those from a *Wilcoxon signed-rank test* as the number of observations strongly varies among combinations of stock and marketplace.

### 3.2 Instrument and Market Choice

The instrument choice is based on the constituents of the Dow Jones EURO STOXX 50 Index as of October 2007 since these represent the actively traded shares on multiple markets in Euro currency. The index covers 50 blue-chip stocks from 12 Eurozone countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. One EURO STOXX 50 instrument (ARCELORMITTAL) was not available in the dataset, therefore the sample finally consists of 49 instruments of the index.

Concerning the execution venues in our sample, we included the European markets trading in Euro currency that feature a fully-electronic open central limit order book (CLOB) in the period under investigation. Therefore, ten markets have been identified for this study: Bolsa de Madrid, Borsa Italiana Milan, Chi-X, the Euronext markets (Amsterdam, Brussels, Paris, and Lisbon), Helsinki Stock Exchange (NASDAQ OMX Helsinki), SWX Europe (formerly Virt-x) and Xetra (Deutsche Börse).

The trading mechanisms of these execution venues for liquid stocks apply continuous trading and opening and closing prices are set via scheduled (time-triggered) call auction mechanisms (Chi-X opening and prices are established using the opening price of a stock's primary market). To assure price continuity, additional volatility interruptions stop continuous trading in case of potential extreme price movements and trigger an unscheduled (event-triggered) auction. Except for Chi-X (the Chi-X trading system does not accept orders leading to a violation of price continuity), all execution venues in our sample shift from continuous trading to a non-scheduled auction for a minimum of two minutes following a potential violation of price continuity.

### 3.3 Description of the Data Set

Intraday trade and order book data for each stock (for each market) are sourced from the archives of Reuters that were made available by the Australian Capital Markets Cooperative Research Centre Limited (CMCRC). For the markets in our sample, this database contains each best bid/offer limit and trade price with respective volume and a date and time stamp with a granularity of one second assigned to it. The data set under investigation represents level 1 data, i.e. it does not include depth of order book information, consisting of orders positioned beyond the top of the book (level 2 data). Reuters trade and order book data do not contain an indication of trade direction, which must therefore be inferred. In the ten fully electronic markets these inferences are straightforward. All trades executed at the best offer are categorised as buy-initiated; all trades executed at the best bid quote categorised as sell-initiated (for further information on tick rules see [18]). Total traded value and other aggregated activity figures for each stock were calculated from the Reuters trade and order book data.

Our sample consists of 20 trading days divided into two distinct sample periods with the first from December 10–21, 2007 and the second from January 7–18, 2008. Altogether 8,010,905 executed trades representing an overall trading volume of 262,314 million € are included in the dataset.

### 3.3 Data Handling and Data Cleaning

For the investigation, our dataset had to be cleaned and prepared in several dimensions. Trade and order book data lacking essential information like e.g. associated volume were eliminated. In the case of order book data, the most recent valid limit orders featuring all information necessary for our analysis were considered for comparison of execution quality. Moreover, trades for which a trade direction could not unambiguously be determined were eliminated from the dataset. Regarding trade sizes no data cleaning measures were required.

As trading hours among the ten electronic markets included in this study vary slightly, for a comparison of markets only the periods of simultaneous trading were taken as a basis. As we focus on continuous trading, auctions times were neglected and additionally, any order book or trading activity within two minutes around scheduled as well as non-scheduled auctions were eliminated from our dataset. As stated before, our dataset contains time stamps for trades and quotes with a granularity of one second. With a quote change in a comparison market arriving within the second of a trade occurrence in our original market this new quote is considered available and thus presents the most recent order book situation to this trade. With more than one quote change within the second of a trade occurrence at one market, the quote resulting in the least savings is taken as a basis for an execution performance comparison in order to retrieve a lower boundary for the possible price improvements.

## 4 Results

Results for trade-throughs will be presented in this section as follows: First, we will deal with our findings on trade-throughs addressing summarising descriptive statistics. This will be followed by an in-depth analysis for an exemplary instrument with our results broken down into the individual markets where that instrument is tradable.

Consequently, our test statistics for the relative and absolute savings will be presented. For all other instruments results will be summarised while abstracting from individual execution venues. From our total of 8,010,905 trades, 6.71% (absolute: 537,764 trades) could have been executed at better price conditions with their full volume (full trade-throughs), 6.45% (absolute: 516,797 trades) at least with a part of their volume (partial trade-throughs). For our sample period and given our selection of instruments and European trading venues investors could have saved € 9.50 million in total and € 9.01 on average per suboptimal order execution (before explicit execution costs) if they had used a Smart Order Routing system which places orders at the best price. The savings add up to 7.54 basis points (bps; 1 bps = 0.01%) relative to total trade-through value and 0.36 bps relative to total traded value.

TOTAL led the EURO STOXX 50 index in terms of market capitalisation as of December 31st, 2007 [19]. Therefore, in the following TOTAL will be taken as an example to explain our key figures in table 1.

**Table 1.** Trade-through statistics for TOTAL

| | Euronext FR | Chi-X | Euronext BR | Milan | SWX Europe | Overall |
|---|---|---|---|---|---|---|
| Number of trades | 293,729 | 26,263 | 465 | 210 | 18 | 320,685 |
| Volume [K shares] | 183,140 | 8,061 | 85 | 31 | 211 | 191,528 |
| Value [K €] | 10,300,568 | 455,751 | 4,787 | 1,715 | 11,860 | 10,773,682 |
| Avg. volume per trade [shares] | 624 | 307 | 183 | 146 | 11,725 | 597.2 |
| Avg. value per trade [€] | 35,065 | 17,353 | 10,295 | 8,167 | 658,883 | 33,595.8 |
| Full trade-throughs [%] | 14.58 | 9.52 | 53.98 | 53.33 | 5.56 | 14.24 |
| Partial trade-throughs [%] | 10.88 | 5.24 | 4.95 | 1.90 | 5.56 | 10.40 |
| Number of trade-throughs | 74,778 | 3,875 | 274 | 116 | 2 | 79,045 |
| Full | 42,815 | 2,499 | 251 | 112 | 1 | 45,678 |
| Partial | 31,963 | 1,376 | 23 | 4 | 1 | 33,367 |
| Savings [€] | 493,219 | 16,679 | 3,360 | 542 | 331 | 514,131 |
| Avg. savings per trade-through [€] | 6.60 | 4.30 | 12.26 | 4.67 | 165.64 | 6.50 |
| Savings / trade-through value [bps] | 4.23 | 3.33 | 12.73 | 8.28 | 51.19 | 4.22 |
| Savings / trade value [bps] | 0.48 | 0.37 | 7.02 | 3.16 | 0.28 | 0.48 |

Table 1 features the results for the individual execution venues. The "Overall" column summarises over all markets. The table's upper section gives an overview on the markets' activity for TOTAL applying characteristic figures. Trade activity varies heavily among market places with the second in number of trades (here: Chi-X) not even measuring up to one tenth of that of the primary exchange (here: Euronext France (FR)). This is a common observation for most stocks in our sample.

The lower section introduces findings on trade-throughs for each market with relative and absolute figures on full and partial trade-throughs. In the example 14.6% or 42,815 out of the 293,729 trades which occurred in Euronext FR could have been executed in its full size at a better price in (at least) one of the other markets. Potential accumulated savings over all trades are shown along with the absolute and relative average savings per trade-through [Avg. savings per trade-through and Savings/trade-through value respectively]. Finally, the savings are related to the total trade value for each market.

Table 2 presents the mean, standard deviation and *t*-statistics of the variables price improvement [PI] and absolute savings [Savings] of TOTAL for each market. It should be noted that the mean PI and Savings are unconditional and therefore are not identical to the Savings / trade-through and Avg. savings per trade-through values respectively from table 1. Except for SWX Europe the null hypotheses of no systematic relative price improvement and absolute savings can be statistically rejected.

**Table 2.** Test statistics for price improvements [PI] and absolute savings [Savings]

| | | Euronext FR | Chi-x | Euronext BR | Milan | SWX Europe |
|---|---|---|---|---|---|---|
| | *N* | 293,729 | 26,263 | 465 | 210 | 18 |
| PI (bps) | Mean | 0.80 | 0.37 | 6.34 | 4.40 | 1.41 |
| $H_0$: PI=0, | Standard deviation | 2.85 | 1.60 | 10.72 | 6.06 | 5.92 |
| $H_a$: PI>0 | *t*-statistic | 152.80*** | 36.98*** | 12.74*** | 10.52*** | 1.01 |
| Savings (€) | Mean | 1.68 | 0.64 | 7.23 | 2.58 | 18.40 |
| $H_0$: Savings=0, | Standard deviation | 7.91 | 3.31 | 22.66 | 6.30 | 72.94 |
| $H_a$: Savings>0 | *t*-statistic | 115.04*** | 31.05*** | 6.88*** | 5.93*** | 1.07 |

*** .01 level of significance

Descriptive overall results for all other instruments are shown in table 3.

**Table 3.** Descriptive statistics of trade-throughs for all instruments

| Instrument | Number of trades | Value [€ mn] | Value/ trade [€] | % full trade-through | % partial trade-through | Savings [€] | Avg. savings /trade-through [€] | Savings /trade-through value [bps] | Savings /trade value [bps] |
|---|---|---|---|---|---|---|---|---|---|
| AEGON | 125,881 | 2,397.4 | 19,045 | 14.30 | 6.24 | 287,978 | 11.14 | 9.72 | 1.20 |
| AIR LIQUIDE | 137,656 | 1,960.0 | 14,238 | 5.21 | 3.68 | 18,804 | 1.54 | 2.35 | 0.10 |
| ALCATEL LUCENT | 117,490 | 1,730.5 | 14,729 | 8.05 | 6.90 | 113,667 | 6.47 | 14.20 | 0.66 |
| ALLIANZ | 190,387 | 8,673.0 | 45,555 | 13.29 | 14.34 | 272,392 | 5.18 | 3.50 | 0.31 |
| ASSICURA-ZIONI GEN-ERALI | 112,315 | 2,984.2 | 26,570 | 0.21 | 0.11 | 3,099 | 8.80 | 5.64 | 0.01 |
| AXA | 208,272 | 5,143.0 | 24,694 | 11.61 | 9.73 | 881,357 | 19.83 | 18.71 | 1.71 |
| BASF | 131,899 | 5,487.2 | 41,602 | 7.43 | 8.24 | 84,518 | 4.09 | 2.81 | 0.15 |
| BAYER | 135,287 | 5,912.6 | 43,704 | 6.19 | 8.47 | 112,074 | 5.65 | 4.16 | 0.19 |
| BCO BILBAO VIZCAYA ARGENT | 137,718 | 6,415.8 | 46,587 | 0.56 | 0.94 | 20,345 | 9.82 | 10.24 | 0.03 |

**Table 3.** (*Continued*)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BCO SANTANDER | 165,497 | 11,024.8 | 66,616 | 11.88 | 22.17 | 2,034,860 | 36.11 | 32.59 | 1.85 |
| BNP PARIBAS | 297,256 | 6,746.5 | 22,696 | 16.70 | 12.86 | 337,179 | 3.84 | 3.86 | 0.50 |
| CARREFOUR SUPERMAR. | 132,166 | 2,726.3 | 20,628 | 4.07 | 3.91 | 22,275 | 2.11 | 2.72 | 0.08 |
| CREDIT AGRICOLE | 144,184 | 2,074.5 | 14,388 | 3.73 | 4.66 | 29,979 | 2.48 | 5.59 | 0.14 |
| DAIMLER | 173,898 | 8,531.9 | 49,063 | 5.94 | 10.72 | 170,043 | 5.87 | 4.97 | 0.20 |
| DEUTSCHE BANK | 189,235 | 8,416.7 | 44,478 | 11.56 | 14.13 | 226,700 | 4.66 | 3.20 | 0.27 |
| DEUTSCHE BOERSE | 96,267 | 3,532.2 | 36,691 | 1.06 | 2.97 | 14,754 | 3.80 | 4.51 | 0.04 |
| DEUTSCHE TELEKOM | 103,617 | 7,702.1 | 74,332 | 9.10 | 7.13 | 141,996 | 8.44 | 5.09 | 0.18 |
| E.ON | 172,070 | 8,778.9 | 51,019 | 8.24 | 13.48 | 466,167 | 12.47 | 8.38 | 0.53 |
| ENEL | 133,043 | 4,158.2 | 31,254 | 1.95 | 1.61 | 207,925 | 43.90 | 54.79 | 0.50 |
| ENI | 171,544 | 5,969.3 | 34,798 | 0.73 | 0.56 | 20,379 | 9.17 | 6.36 | 0.03 |
| FORTIS | 230,052 | 5,672.3 | 24,656 | 16.51 | 7.92 | 488,988 | 8.70 | 6.25 | 0.86 |
| FRANCE TELECOM | 210,668 | 5,190.2 | 24,637 | 6.16 | 4.55 | 121,109 | 5.36 | 5.43 | 0.23 |
| GRP DANONE | 170,115 | 3,192.2 | 18,765 | 0.39 | 0.31 | 21,806 | 18.28 | 19.59 | 0.07 |
| GRP SOCIETE GENERALE | 246,933 | 6,323.9 | 25,610 | 2.01 | 1.57 | 161,869 | 18.32 | 14.31 | 0.26 |
| IBERDROLA | 98,281 | 4,285.8 | 43,608 | 0.16 | 0.39 | 8,396 | 15.49 | 25.67 | 0.02 |
| ING GROEP | 183,835 | 5,913.2 | 32,166 | 3.83 | 1.76 | 224,677 | 21.85 | 10.60 | 0.38 |
| INTESA SANPAOLO | 119,681 | 4,805.5 | 40,153 | 0.49 | 0.17 | 20,275 | 25.66 | 11.56 | 0.04 |
| L'OREAL | 137,517 | 2,327.6 | 16,926 | 3.72 | 4.35 | 27,480 | 2.48 | 4.30 | 0.12 |
| LVMH MOET HENNESSY | 150,690 | 2,710.5 | 17,987 | 3.73 | 4.44 | 26,264 | 2.13 | 3.60 | 0.10 |
| MUENCHEN-ER RUECK | 120,327 | 4,607.9 | 38,295 | 9.58 | 8.82 | 88,364 | 3.99 | 2.64 | 0.19 |
| NOKIA | 179,301 | 9,235.7 | 51,509 | 2.39 | 3.11 | 167,993 | 17.05 | 10.57 | 0.18 |
| PHILIPS ELECTRON-ICS | 202,630 | 5,368.0 | 26,492 | 11.32 | 6.29 | 286,566 | 8.03 | 5.73 | 0.53 |
| RENAULT | 171,747 | 3,104.4 | 18,075 | 3.75 | 4.68 | 38,316 | 2.65 | 4.46 | 0.12 |
| REPSOL YPF | 95,611 | 2,631.3 | 27,521 | 0.30 | 1.05 | 57,300 | 44.38 | 118.40 | 0.22 |
| RWE | 132,587 | 5,712.3 | 43,083 | 5.00 | 8.56 | 75,185 | 4.18 | 3.99 | 0.13 |
| SAINT GOBAIN | 158,017 | 2,521.0 | 15,954 | 5.25 | 5.83 | 73,193 | 4.18 | 7.47 | 0.29 |
| SANOFI-AVENTIS | 209,655 | 6,004.3 | 28,639 | 6.10 | 5.22 | 95,685 | 4.03 | 3.46 | 0.16 |
| SAP | 118,283 | 4,972.4 | 42,038 | 4.81 | 6.23 | 115,952 | 8.88 | 6.51 | 0.23 |
| SCHNEIDER ELECTRIC | 147,489 | 2,321.4 | 15,739 | 3.84 | 4.99 | 24,692 | 1.90 | 3.78 | 0.11 |
| SIEMENS | 190,914 | 10,639.8 | 55,731 | 7.43 | 11.92 | 478,100 | 12.94 | 8.29 | 0.45 |
| SUEZ | 194,471 | 4,723.2 | 24,287 | 8.00 | 7.06 | 146,770 | 5.01 | 5.14 | 0.31 |
| TELECOM ITALIA | 100,334 | 3,790.0 | 37,774 | 0.60 | 0.80 | 16,924 | 12.08 | 12.75 | 0.04 |
| TELEFONICA | 171,690 | 8,535.1 | 49,712 | 4.14 | 8.27 | 109,178 | 5.12 | 7.19 | 0.13 |
| TOTAL | 320,685 | 10,773.7 | 33,596 | 14.24 | 10.40 | 514,131 | 6.50 | 4.22 | 0.48 |

**Table 3.** (*Continued*)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| UNICREDITO ITALIANO | 215,043 | 11,573.4 | 53,819 | 1.29 | 0.85 | 110,155 | 23.98 | 13.14 | 0.10 |
| UNILEVER NV | 184,066 | 4,809.7 | 26,130 | 10.33 | 5.03 | 260,660 | 9.22 | 5.92 | 0.54 |
| VINCI | 193,968 | 2,890.0 | 14,899 | 5.46 | 3.90 | 122,639 | 6.75 | 12.18 | 0.42 |
| VIVENDI | 162,783 | 3,092.6 | 18,998 | 4.87 | 5.32 | 67,594 | 4.08 | 5.21 | 0.22 |
| VOLKSWAG-EN | 117,850 | 4,221.5 | 35,821 | 9.02 | 9.03 | 86,120 | 4.05 | 2.97 | 0.20 |
| ALL IN-STRUMENTS | 8,010,905 | 262,313.9 | 32,745 | 6.71 | 6.45 | 9,502,869 | 9.01 | 7.54 | 0.36 |

Generally, our findings exhibit a high level of heterogeneity among instruments regarding the trade-through characteristics with the minimum of full trade-through percentage at 0.16 and the maximum at 16.7 percent. Table 4 summarises those results for our sample of 49 instruments.[2]

**Table 4.** Summary statistics of trade-through key figures over all instruments

| | % Trade-throughs | | Avg. savings per trade-through [€] | Savings / trade-through value [bps] | Savings / trade value [bps] |
|---|---|---|---|---|---|
| *N*=49 | Full | Partial | | | |
| Mean | 6.05 | 6.03 | 10.46 | 11.20 | 0.32 |
| Standard deviation | 4.54 | 4.58 | 10.08 | 18.05 | 0.38 |
| Minimum | 0.16 | 0.11 | 1.54 | 2.35 | 0.01 |
| 1st quartile | 2.39 | 2.97 | 4.08 | 4.16 | 0.11 |
| Median | 5.21 | 5.22 | 6.50 | 5.73 | 0.20 |
| 3rd quartile | 9.02 | 8.47 | 12.47 | 10.60 | 0.42 |
| Maximum | 16.70 | 22.17 | 44.38 | 118.40 | 1.85 |
| *t*-statistic | 9.33*** | 9.22*** | 7.47*** | 4.54*** | 5.98*** |

*** .01 level of significance

Results show that investors could have realised significant savings on their trades across all instruments resulting from executions at the best prices available based on sophisticated Smart Order Routing technology.

## 5 Conclusion

In fragmented equity markets, Smart Order Routing systems promise to generate economic value by electronically accessing the best available bid and offer among the execution venues where the respective security is traded. After the introduction of

[2] Please notice that the means in table 4 have been computed as un-weighted averages over all 49 instruments and thus differ from the figures for “All Instruments“ in table 3 which are averages over all trades.

MiFID, the European trading landscape moved from concentration rules to relevant fragmentation and the best execution rules imposed by MiFID urge investment firms to achieve the best possible result for their customers. Against this background, the paper assesses the economic relevance of Smart Order Routing engines based on a four week data set of EURO STOXX 50 securities consisting of 8 million executed trades with an overall value of € 262 billion. The analysis shows that on a gross basis there is a relevant and statistically significant extent of suboptimal order executions where a different execution venue provides a better executable limit: 6.71% of orders can be executed better in their full size (6.45% of orders partially) enabling for total savings of € 9.5 million, i.e. 7.54 bps relative to total trade-through value and 0.36 bps relative to total traded value. With that evidence on hand we can conclude that Smart Order Routing Technology enables for relevant improvements in order execution and thereby can generate positive business value in European equity markets.

An obvious next step in the research project is the inclusion of trading, clearing and (cross-system) settlement costs. While the execution venues differ in their domestic costs structures, the main driver of explicit costs are the cross-border/cross-system settlement costs.

Based on these net results, further analysis may focus on the one hand on the explanation of the main drivers for both suboptimal order executions and on the other hand on the inclusion of data on the order book depth of the respective markets to extend the concept of full trade-through to all the trades and eliminate the partial trade-through approach. Thereby, the research project both can contribute to the assessment of the economic value of Smart Order Routing technology as well as to its actual design and technical implementation.

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