The Digitalization of Financial Markets

The Socioeconomic Impact of Financial Technologies

Edited by
Adam Marszk and
Ewa Lechman

First published 2021

ISBN: 978-0-367-55834-5 (hbk)
ISBN: 978-0-367-55840-6 (pbk)
ISBN: 978-1-003-09535-4 (ebk)

2 European financial institution physical geolocation and the high-frequency trading potential

Piotr Staszkiewicz, Ewa Łosiewicz-Dniestrzańska and Anna Grygiel-Tomaszewska

DOI: 10.4324/9781003095354-2

The funder for this chapter is Wroclaw University of Economics and Business

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

2 European financial institution physical geolocation and the high-frequency trading potential

Piotr Staszkiewicz, Ewa Łosiewicz-Dniestrzańska and Anna Grygiel-Tomaszewska

Introduction

The concept of algorithmic trading is associated with the use of procedures and algorithms to make trading transactions, usually without the active participation of humans. High-frequency trading (HFT) is a sub-area of algorithmic trading. Contrary to latent trading, HFT applies the technological solution of speeding the transaction both in terms of placing and execution. The ability of the financial institution to gain a competitive advantage with the use of HFT is conditioned upon the relevant technology, distance to the stock exchange server, stock exchange regulation, and technological fit, thus it is viewed as part of the fintech financial ecosystem (Marszk et al., 2019). The investments institutions might place their servers close to the stock exchange servers thus reducing the distance of the connection (Frino et al., 2020). Because of the placement of the hardware, the time necessary to place and execute the order is shortened. Therefore, the trader gains a competitive advantage over other market participants.

To equalize the participants, the condition applies regarding the colocation of the trading servers around the stock exchange servers. This prevents only a part of the problem as the traders are legally bound to replicate the physical servers at their main seat of operation. Thus, the alternative safety procedures (e.g., to prevent flash crises) are still driven by the physical distance, which impacts the trader's profitability. Also, because the HFT on a specific stock exchange is conditioned on individual technological requirements, we lack the methodology to compare piecemeal activities on exchanges for the traders who utilize passports. A combination of those two factors contributes to the purpose of the presented research.

This research aims to provide robust evidence about the profitability of the market's direct and indirect participants conditioned upon the physical distance to the main stock exchange. The proposal builds up and extends the prior research of Staszkiewicz (2015a) and Aitken et al. (2017), among others, by widening the scope and dynamics. It advances prior analyses with the dynamic of the phenomenon and contributes to the current literature on the HFT with several aspects. Firstly, it provides robust evidence on

DOI: 10.4324/9781003095354-2

the investment institution return development across Europe. Secondly, it discusses the potential combination of merging the geolocation and regression analysis for the different stock comparisons. Thirdly, it generalizes piecemeal observations from different European economies into a more comprehensive framework.

Literature review and hypotheses development

General remarks

Following the general development of means of communication, the methods and techniques of asset trading also changed. Adopting intelligent algorithms to place and execute transactions with the use of high-speed internet enables some market participants to reach for new sources of performance advantages that are developed based on quotation volatility within milliseconds. Such algorithms provide investors with a certain upside compared to others. They also impact entire markets and their structure as we know it, beginning with questioning the paradigm of equal access to price information for all investors, to the change of perception of quotations – from traditional: discrete, to modern: close to continuous. Which in turn might jeopardize the efficiency of market allocation of scarce resources (Diaz-Rainey & Ibikunle, 2012; Upson & Van Ness, 2017; Weller, 2018; Wurgler, 2000).

HFT, being a variation of algorithmic trading, is recognized as one of the tools aimed at facilitating transactions on various asset classes, e.g., bonds, shares, futures, listed options, Interest Rate Swaps (IRS), currencies (MacKenzie et al., 2020), as well as cryptocurrencies, thus allowing to generate profit, based on short term volatility of quotations. The latest available data from the European Securities and Markets Authority (ESMA) prove that in Europe in 2014 HFT transactions amounted to as much as between 30% and 49% of equity trades and 58% to 76% of equity orders (Roqueiro et al., 2016). Robust HFT development raises questions regarding many areas of the influence of this type of transaction on markets and their participants. Abrupt and significant popularity of HFT and the specifics of HFT-based strategies (proven e.g., by the discrepancy in the percentage of orders and trades) result in the urge to regulate and supervise them (Meyer & Guernsey, 2017) also from the perspective of the protection of the ordinary (latent) market participants. However, since the impact of HFT on markets is complex, there are differences in regulatory and market approaches towards this type of transaction placement and execution (Korajczyk & Murphy, 2019; Meyer & Guernsey, 2017; Van Kervel & Menkveld, 2019).

Among others, the robust development of HFT raises also inevitable questions regarding the actual factors that contribute to the profitability of these transactions and their origin. One of which might be an operational advantage derived from the physical distance between the investor or broker server and the stock exchange server. Since in HFT, apart from the quality of algorithms, it is the actual speed of the information transfer that constitutes the potential trading upside, the shorter the distance it travels, the higher the return it generates. Thus, it is the physical distance of the servers that possibly affects the trade performance due to possible delays in trade-related information transfer.

High-frequency trading

HFT generates trading impulses to make and execute investment decisions (Labadie & Lehalle, 2010). Therefore, such decisions are free from the judgmental bias of human decisions and benefit from prompt trading sequencing. However, HFT is not homogeneous. There are two subsegments of HFT – flash trading and ultra HFT. Apart from minor differences, both are based on the ability to acquire certain information sooner than other market participants. In extreme cases, it may refer to information about orders placed by other investors, which could be recognized as a powerful upside (Chlistalla, 2011).

HFT is aimed at gaining performance advantage, especially over the classic latent trading, based on the reduction of time necessary for trading operations, combined with the exposure to millisecond differences in quotations of given assets. The expected outperformance is derived from the small profit of a single price variance multiplied by the significant volume of trade, along with the short time of holding position (on average it is less than five seconds, often less than one second) and time for order placement shorter than one millisecond (Lenczewski-Martins, 2017). HFT demands that certain technical requirements be met, which include infrastructure that is intended to minimize latency and IT software systems that decide to initiate, generate, route, or execute an order without human intervention (Francioni et al., 2017). Considering the specific features of HFT, their application is not limited solely to speculation, but also includes market-making, arbitrage, or inter-market spreading (Staszkiewicz & Staszkiewicz, 2015).

As a consequence of HFT, robust development can be analyzed both from the perspective of the market itself, as well as from the perspective of a unique (single) market participant. From the market perspective, it was proven that HFT supports growth in trading liquidity while at the same time reducing transaction costs and market risk (Meyer & Guernsey, 2017; Watkins, 2014). Raddant and Wagner (2017) also confirmed the positive impact of HFT on market efficiency, supported by lower price fluctuations and thus resulting in increased surplus and lower returns. Essendorfer et al. (2015) noticed that the increase in the speed of transactions as well as of market turnover is also credited to HFT.

However, apart from its positive impact, the abrupt and robust development of HFT as well as its expected constant refinement can be recognized as a source of additional risk to markets. Some research confirms that the robust development of HFT is related to certain negative outcome. Essendorfer et al. (2015) point to the fact that along with the growth of HFT, the average size of a single trade is reducing. Markets suffer from liquidity fragmentation and periods of excess volatility that result in flash crashes. Apart from this, the obvious consequence of HFT's robust development is that the role of a human trader becomes less and less significant in the market (Essendorfer et al., 2015).

Taking the above into consideration, both market participants and market regulators take specific controlling activities. Gong et al. (2018) noticed that in periods of bid-ask spreads being widened, CSI 300 index HFT investors need to take steps to diminish potential liquidity risk. To prevent HFT domination and the negative results of it, certain general legal restrictions, like MiFID II, were launched. HFT and other forms of algorithmic trading are not themselves directly covered by the supervisory regime of MiFID II. However, if investment firms wish to provide direct electronic access (DEA) to their clients to carry out HFT or other algorithmic transactions, they are also subject to a specific form of supervision (Busch, 2016). Also, trading companies themselves report that they use specific cap mechanisms to prevent too excessive, too abnormal returns (MacKenzie et al., 2020).

From the perspective of the HFT market single participant, the expected value-added by the use of this type of transaction may be reflected in the abnormal rate of return, exceeding the market return, also when trading in the direction of asset price jumps (Fičura, 2019). Certainly, the performance of an investor can be credited to several elements. Part of the performance can be explained with the market characteristics, including quotation volatility, asset type, and asset liquidity. However, HFT is also an invisible arena of a specific armaments race, where the quality of the trading system and of the algorithm itself may generate expected performance upsides. Thirdly, since HFT is applied mainly on markets with dematerialized quotations and with the use of electronic transaction systems, the physical distance of the trader's server and the market server may influence the result of a transaction.

Colocation

HFT strategies barely rely on fundamentals, deriving their success mostly from the ability of the trading system to place and execute the transaction with a minimum time lag. All transactions on dematerialized markets are placed and executed with the use of certain electronic systems. Therefore, this time lag depends on the speed of communication between the server of the broker or the investor and the market server (e.g., stock exchange server). If so, the physical distance between them influences the latency of quotation information and the time lag between the placing and execution of the order, which in turn impacts the trade performance.

The relationship between colocation and general performance was proven for various types of businesses (Ivarsson et al., 2017; Kudic et al., 2016; Zubcsek et al., 2017), as well as from the sociological standpoint (Tabuchi, 2019). However, there is still little coverage of the problem of the relationship between the performance of HFT market participant companies and the colocation of servers.

As early as the beginning of the 21st century, Hau (2001) confirmed that the performance of market participants is influenced by the location of the trader. Since this research was biased with internal stock exchange data sourcing, Staszkiewicz and Staszkiewicz (2015) proposed to analyze this potential impact of colocation on the performance of brokers with the independent variable geolocation of the market participant as a proxy of its potential HFT abilities.

Conrad et al. (2015) investigated the relationship between the launch of HFT to the Tokyo Stock Exchange and the quotation patterns. Their research resulted in the conclusion that HFT allowed to reduce both latency and trading costs significantly and allow the colocation of servers. They have also noticed the quotation patterns to be more random-walk resembling.

Research gap and hypothesis formulation

Current literature fails either to discuss the impact of HFT on the entire network of recognized financial markets or does not necessarily distinguish the function of the supervised and not supervised market players.

Since modern dematerialized markets allow distant order placement and execution, part of the performance of HFT market participants should be explained by the physical distance between servers of traders and the market (stock exchange). As the licensed companies might have direct access to the recognized financial market and might have inherent credibility due to the supervision processes, we verify whether there are any differences in the performance of licensed vs. non-licensed market participants. Taking the above into consideration, we hypothesize that:

H_{01}: There is a difference in performance between supervised and not supervised financial institutions.

The differentiation between successful and unsuccessful trading strategies relies on their performance. Thus, we analyze the influence of colocation on the performance of market participants, aggregated at their return on assets (RoA). Therefore, we hypothesize that:

H_{02}: RoA is affected by distance to the nearest stock exchange.

Following prior research, we extend the perspective from neighboring financial markets into the whole network of financial markets in Europe. Thus, we formulate our third working hypothesis that:

H_{03}: The geographical position of the financial institution within the net of the European recognized financial markets impacts performance.

Suppose our hypothesis should be confirmed, then there would be a clear message to the financial authorities to adjust the market participant's rules as the sole geographical position would impact the fairness of trading. On the contrary, rejection of the set of hypotheses above would indicate that each stock exchange's local setting plays a substantial role in driving the HFT's transaction.

Methodology and data set

Methodology

Our basic approach is to regress the performance of the financial institution in terms of the distance to the stock exchange. Direct access to the stock server requires licensing, thus, to verify our hypotheses we contrast supervised and non-supervised entities across different financial markets.

This study uses the univariate and multivariate statistical analysis of the archived data. The research applies both the geocoding distance calculation based on the seat of the traders and stock exchange and the regression analysis of the institution's return on equity (RoE). The study follows prior research of Hau (2001) on the German market and Staszkiewicz and Staszkiewicz (2015) and Staszkiewicz (2015a) on the Polish and Central European markets.

The approximation of the distance between any two different locations A and B is given by the following formula:

$$d = \frac{2\pi q R}{360}, \tag{2.1}$$

where: $\pi = 3.1415\ldots$, $R = 6371$ km (average radius of the Earth), and q is the solid angle between points A and B.

Prior studies applied RoE as a measurement, however, the performance measured concerning the equity tends to be endogenous, as the unallocated profit impacts total shareholders' resources, thus we based our approach on RoA. To account for potential biases resulting from not including all possible variables that drive performance, we applied a dynamic panel with the difference and system generalized method-of-moments (GMM) estimators (Roodman, 2009). The application of the GMM was developed by Arellano and Bond (1991), enhanced by Arellano and Bover (1995), and further developed in Blundell and Bond (1998).

The GMM estimator requires two conditions. Firstly, that the overidentifying restrictions are valid. Secondly, it does not allow the presence of second-order serial correlation in the error term. The Hansen test shows the overall validity of the instruments while Arellano and Bond's test verifies the presence of the second-order correlation.

Table 2.1 Summary of definitions of variables and expected direction

Name of the variable	*Symbol*	*Definitions*
RoA	Y	RoA is the net profit divided by the total assets (a response variable)
Assets	x_1	Natural logarithm of the total assets
Consol_level	x_2	A factorial variable: (1) Consolidated accounts with no unconsolidated companion; (2) Consolidated accounts with an unconsolidated companion; (3) Unconsolidated accounts with no consolidated companion; (4) Unconsolidated accounts with a consolidated companion
Supervised	x_3	A binary variable, a value of 1 indicates the licensed entity otherwise 0
Cap_Requ	x_4	Relation of the core capital to the total assets
NACE_Rev	x_5	6419 – Other monetary intermediation, 6499 – Other financial service activities, except insurance and pension funding
MIN	x_6	Distance to the closest stock exchange from the seat of the company

Source: own presentation.

The analytical equation of the model of the panel data is shown below:

$$y_{i,t} = \omega y_{i,t-1} + \sum_{j=1}^{k} \beta_j x_{j,i,t} + \sum_{l=1}^{m} \delta_l z_{l,i} + \sum_{r=1}^{f} \gamma_r c_{r,i,t} + \alpha_i + \mu_{i,t} \ , \tag{2.2}$$

where: $y_{i,t}$ = response variable - RoA, $x_{j,i,t}$ = independent variables time-variant, $z_{l,i}$ = independent variable time-invariant, $c_{r,i,t}$ = control variables, and $\omega, \beta, \delta, \gamma$ = parameters, $\alpha_{i\,=}$ individual effects, $u_{i,t}$ = error term. Table 2.1 presents the definitions of the variables.

Development of the variables in the equation

Many articles explain possible sources of return for an investment company. Part of previous research points out the influence of home bias, regarded as asymmetry of information between local and external market participants (Staszkiewicz, 2015b). The home biases might be attributed to different aspects like market liberalization (Dahlquist & Robertsson, 2004), market size (Portes & Rey, 2005), and investors' perceptions (Brennan et al., 2005). Home bias is additionally supported by the shift from inside trading to market informational efficiency (Halling et al., 2007). Since the relationship between country and return is not unequivocal, it can be treated only as a control variable.

Assets and their volume are also expected to influence the performance of a company. In this regard, there are adverse approaches in the literature. Financial institutions that are subject to independent authority supervision at the same time are obliged to meet certain capital requirements. Therefore, from their perspective, a certain level of assets is expected to be kept to balance their operational risks. However, the research of Teixeira et al. (2014) proved that the banking sector is overcapitalized and that capital requirements have a low impact on the level of capital held by banks.

These findings are also contrary to Mishkin's (2000) claims that bank executives prefer to maintain capital levels lower than required to minimize the cost of capital. However, with that in mind, it is important to include in the model the fact that compared to non-regulated companies – regulated companies are affected by capital requirements. Therefore, the authors included "license" as a binary variable, indicating whether the market participant is or is not a licensed entity.

Fama and French (1993) ascertained the negative relation between size and return and Buchuk et al. (2014) noticed that there is a positive correlation between RoE and the fact that the company is borrowing capital within a capital group. Since the literature shows multiple factors that may influence RoE, in our model they are treated as control variables. The tested variables are the distance of the company seat within one km to the stock exchange and the distance within three km to the stock exchange.

Datasets

We collected data from the Orbis database (Van Dijk, 2020). We based our research on the NACE Rev. 2[1] classification of entities. We examined the population of the entities classified under code numbers 6419 – other monetary intermediation and 6499 – other financial service activities, except insurance and pension funding, which had the seat in the European Union (EU) administrative region. We considered entries with ten years of consecutive reporting history to rectify the noise raised for newcomers and insolvent companies. Our population contains both supervised and unsupervised institutions. We identified the entities subject to the supervision scrutiny by reference to the ESMA registers. We geocoded the addresses of entities with the application of the Google Geocoding API. We also geocoded the unrecognized addressees manually. The data period ranges from 2010 to 2019. The cut-off year of 2010 was taken to avoid the impact of the liquidity crisis 2007–2009. The identification of our population resulted in 4,964 entities. Table 2.2 presents the identification of the population.

From the total population identified, we drew a random sample. Table 2.3 shows the geographical distribution and the structure of the final sample versus the population.

Table 2.2 Usable sample identification

Search step		*Search result*
Status	Active companies, unknown situation	283,459,876
NACE Rev. 2 (Primary codes only)	6419 – Other monetary intermediation, 6499 – Other financial service activities, except insurance and pension funding	1,716,734
World region/Country/ Region in country	EU [27]	144,120
Number of years with accounts	10 years	13,800
Years with available accounts	2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019	4,964
Total		4,964

Source: own calculation.

Table 2.3 The geographical distribution of the population and sample with the number of supervised entities in the sample

	Country	*Population*	*Sample*	*Supervised in sample*
PT	Portugal	1		
AT	Austria	17	2	2
BE	Belgium	102	15	7
BG	Bulgaria	45		
CY	Cyprus	1		
CZ	Czech Republic	19	2	2
DE	Germany	5	1	0
DK	Denmark	1		
EE	Estonia	23		
ES	Spain	5	3	1
FI	Finland	812	116	28
FR	France	12	3	0
IE	Ireland	212	32	15
IT	Italy	135	52	16
LT	Lithuania	104	2	2
LV	Latvia	42	4	1
NL	Netherlands	14	1	0
SE	Sweden	3406	146	56
SK	Slovakia	8	1	0
	Total	4964	380	130

Source: own presentation.

Our final usable sample consists of 380 entities and 3,800 firm-yearly observations.

The output data were reviewed for consistency and manual corrections were made for the missing coding. The calculation was performed using the application of the R environment (R Core Team, 2018) and Stata (StataCorp., 2020).

Results

General overview

The available research shows that there is a significant HFT market in Europe. Following this, we understand, that it should be reflected in the performance of investment companies that operate in this market. Therefore, if a company is active in the HFT market in Europe, that fact should be reflected in its RoA. Since the performance of HFT is closely related to the colocation of servers, the lower the distance, the higher the return on HFT activities. Therefore, entities that are licensed market participants should generate statistically important overperformance compared to non-regulated investors.

Descriptive statistics

Table 2.4 presents descriptive statistics.

In general, the majority of the companies report losses, the sample comprises all possible consolidation levels and approximately one-third of the sample relates to the supervised firms. The sample is not homogenous in terms of the capital requirements values.

Multivariate statistics

Below we report the results of the estimation of Equation (2) with an application of the system estimator (GMM). Table 2.5 shows the results of the system estimators.

Table 2.4 Descriptive statistics

	Count	*Mean*	*SD*	*Min*	*Max*
RoE	3,658	−.5030116	28.61369	−1713.941	61.67882
Assets	3,750	15.68583	2.158306	.6931472	23.74914
Consol_level	3,800	3.063158	.5678131	1	4
Supervised	3,800	.3421053	.4744771	0	1
Cap_Requ	3,740	−1487.004	64,197.53	−3,266,293	1.5
MIN	3,800	117.7404	159.8923	.1080127	968.9037
N	3,800				

Source: own calculation.

Table 2.5 The system estimator results

	RoA			
	B	*se*	*t*	*P*
L.RoA	−.0048863	.1165961	−.041908	.966572
Assets	100.6086	312.1279	.3223312	.7472018
Consol_level	−1,657.305	3,163.966	−.5238061	.6004134
Supervised	2,385.651	3,528.241	.6761587	.4989399
NACE_Rev	.1098518	1.669847	.0657856	.9475485
Cap_Requ	−.0017002	.0043083	−.3946317	.6931147
MIN	16.32827	25.6398	.6368331	.5242335
2010.year	0	-	-	-
2011.year	0	-	-	-
2012.year	−5.390294	17.39304	−.3099111	.7566286
2013.year	−7.188539	24.41637	−.2944148	.768441
2014.year	−12.93544	45.79548	−.282461	.77759
2015.year	−16.87024	57.51939	−.2932966	.7692955
2016.year	−22.37026	71.34475	−.3135516	.7538617
2017.year	−17.22126	52.77464	−.3263169	.7441846
2018.year	−6.059709	27.68973	−.2188432	.8267722
2019.year	−9.336774	32.42388	−.2879598	.7733775
_cons	0	-	-	-
N		3274		
Hansen		16.81		
Sargan		2,279.3		
AR(2) p-value		0.607		

Source: own presentation.

Our results are controlled with the yearly effects, none of the variables in dispute significantly affect the RoA. We also tested the stock exchange's individual effects, shown in Table 2.6.

Appendix 1 presents the definitions of the stock exchange's name abbreviations.

The results do not indicate any specific stock exchange significant effect.

Research gap verification

To avoid the bias of the authors' judgmental selection of papers, scientific sources with substantial impact on the literature were identified by regressing citation counts on prior publications' metadata collected from the Web of Science Core Collection, based on the method developed by Staszkiewicz (2019). We applied this method to the colocation and HFT literature published between January 2015 and June 2020. We verified the research gap with the application of the citation count regression. We enhanced the initial literature review with the Business and Economics perspective and Web of Science Index. Out of the population of 132 papers selected this way, none of the important papers were omitted in our literature review.

Table 2.6 Stock exchange's individual effects

	RoA			
	B	*se*	*t*	*P*
L.RoA	−.4563728	.0276964	−16.47768	0
Assets	221.3951	189.891	1.165907	.2436522
Consol_level	27,193.58	5,658,695	.0048056	.9961657
Supervised	0	-	-	-
NACE_Rev	479.9743	18,305.98	.0262195	.9790822
2010.year	0	-	-	-
2011.year	0	-	-	-
2012.year	−13.43831	12.28758	−1.09365	.2741086
2013.year	−20.71188	17.68398	−1.171222	.2415094
2014.year	−31.30272	28.76113	−1.088369	.2764323
2015.year	−43.56381	37.41446	−1.164358	.2442791
2016.year	−57.55229	51.33885	−1.121028	.2622759
2017.year	−51.80147	42.71453	−1.212736	.2252306
2018.year	−35.3467	24.967	−1.415737	.1568526
2019.year	−44.3002	31.65284	−1.399565	.1616437
WB_AG	0	-	-	-
B_EB	−550.2736	71,869.22	−.0076566	.993891
BL_BSE	0	-	-	-
C_CSE	0	-	-	-
CZ_PSE	−1749.61	29,497.66	−.0593135	.9527024
D_CSE	0	-	-	-
E_NASDAQ	0	-	-	-
F_NASDAQ	−83.62739	12,423.73	−.0067313	.9946293
FR_EURO	0	-	-	-
D_DB	0	-	-	-
G_AE	0	-	-	-
HSE	0	-	-	-
IR_ISE	591.5214	29,382.84	.0201315	.9839385
I_BI	116.7536	25,177.45	.0046372	.9963
LA_NASDAQ	−344.0065	16,701.51	−.0205973	.9835669
LI_NASDAQ	90.84748	-	-	-
LUX_SBL	0	-	-	-
M_MSE	−611.0242	48,770.69	−.0125285	.990004
NL_NYSE	0	-	-	-
PL_WSE	0	-	-	-
PO_ERONEXT	0	-	-	-
RO_BSE	0	-	-	-
SK_BSE	2,163.648	90,661.88	.023865	.9809603
SO	0	-	-	-
ESP_BVB	95.293	2,516.221	.0378715	.9697902
SW__NASDAQ	0	-	-	-
UK_LIFFE	0	-	-	-
UK_LME	0	-	-	-
UK_ICE	0	-	-	-
IR_NASDAQ	−701.5924	2,2168.3	−.0316484	.9747524
NOR_OB	671.1461	31,731.82	.0211506	.9831255
R_ME	0	-	-	-
S_SE	0	-	-	-
U_USE	0	-	-	-

Table 2.6 (Continued)

	RoA			
	B	*se*	*t*	*P*
_cons	−1,875,886	2.85e+07	−.0658719	.9474798
N		3284		
Hansen		35.61		
Sargan		1730.1		
AR(2) p-value		0.397		

Source: own presentation.

Discussion and conclusion

The estimations of ESMA suggest that HFT activities are a significant part of equity trading in Europe. With that in mind, we expected that this fact should be reflected in the return of market participants. Particularly, it should impact the return on their assets, leading to a conclusion that the shorter the distance between market servers and the server of the investment company, the higher the performance of such a company. Therefore, there should be a statistically important correlation between the colocation of servers and the performance of an investment company. Our research proves that there is no such correlation. This stresses the fact that the ESMA perspective, however, relates more to turnover and liquidity than to the number of market participants.

The results of our research show that all three hypotheses formed, should be rejected. We cannot confirm that there is a difference in performance between supervised and not supervised financial institutions. Also, investment company performance measured with RoA is not affected by the physical distance to the nearest stock exchange. Thirdly, the geographical position of the financial institution within the net of the European recognized financial markets does not impact its performance. The distance to exchanges was then not a decision-taker parameter for broker-dealer return.

Although our findings do not confirm any relationship between investment company performance and colocation, they lead us to certain conclusions. Entities that operate a close distance to the market are mainly local investment companies and banks. For such entities, short distances to market servers may not be a sufficient proxy of their HFT capabilities. It is worth mentioning here, that markets of Central and Eastern Europe were heavily covered by the entities with EU passports with the main seats in the UK. Brexit created a chance to change this status quo, opening the gate of opportunities for local financial institutions.

The relationship between the performance of HFT companies and the colocation of trader's and market's servers was however of little coverage. Still, taking into consideration the previous research, the performance of HFT should partly be explained by the physical colocation of servers. However, it is not the only determining element. As our findings do not necessarily comply with prior results (Ivarsson et al., 2017; Kudic et al., 2016; Zubcsek et al., 2017), this might imply further conclusions that the European markets more prudently apply the rules for the colocation of servers.

Our findings stay in line with the research of Hau (2001) and Staszkiewicz (2015a) in respect of the impact of distance on the performance of Central and Eastern European investment companies. Also, these findings showed that there is no evidence of such a correlation. As our research takes into account both supervised and non-supervised entities and a wider population of investment companies, it can be concluded, that the HFTs in the EU are likely to be dominated by a few market players, like BATS Chi-X Europe (Ibikunle, 2018), who gain a competitive advantage due to technological development and individual access to the trading book building.

The relationship between the colocation of servers and the performance of companies was confirmed for the US market (Shkilko & Sokolov, 2020), but it seems it does not apply identically to the EU markets. This fact leads to the natural question of a difference in price quotations between European and US markets. If the price quotation on European markets allows price volatility on a very distant decimal level, it obviously would give leverage only to a small group of market players. In such a situation, only high-volume transactions would allow outperforming on HFT, as only residual price difference multiplied by assets of large volume would allow for a meaningful return on HFT.

This would result in a high RoE being shared by a very limited group of market participants, therefore potential performance-colocation relationships may not be observable in a large-scale population. In our opinion, the rejection of our testing hypotheses might indicate that the real economy is being diluted within a large group of investment companies, a significant majority of which do not have asset capabilities and technical knowledge to participate in the HFT market at all.

Alternatively, the results might be explained with the identification of the investments institution population. Our research strategy relies on coherent reporting and gathering data in a financial database; however, we cannot exclude the situation that the HFTs traders were misclassified to the high-tech companies instead of the financial institution due to the core activities mismatch.

Our dataset is inherently limited in terms of financial data quality. Throughout the study, we assumed that the potential modification of the audit ports does not significantly impact our findings. We based our assumption on the fact that the modifications themselves are infrequent (Carson et al., 2013).

Another limitation of the study is based on the lack of information regarding the methods of order placement by HFT market participants. Theoretically, the shorter the distance between the broker's server and the market server, the higher the performance rate. However, it also depends on the quality of cable or radio infrastructure that is used as well as on the weather conditions (Shkilko & Sokolov, 2020). The cable connection is constrained by the physical limitation of the possible ground path, on the other hand, the radio connection suffers from weather conditions and surface fluctuation. The last one opens an interesting field for further research.

The equity trading market is fragmented in its latent segment. This is contrary to the HFT market, which may be strongly concentrated and where there is a limited number of participants with assets of significant volume at their disposal. Their possible market advantage relies on these assets as well as on the quality of algorithms used. This may, in turn, lead to the continuous widening of market quotations. From this perspective, legal regulations enforcing the colocation of servers gain new sense in terms of the protection of latent participants.

Acknowledgment

The research was funded by grant no B701084 - Faculty of Economics and Finance, Wroclaw University of Economics and Business, Poland.

Note

1. NACE is derived from the French title "Nomenclature générale des Activités économiques dans les Communautés Européennes" (Statistical classification of economic activities in the European Communities).

References

Aitken, M., Cumming, D., & Zhan, F. (2017). Trade size, high-frequency trading, and colocation around the world. *The European Journal of Finance*, *23*(7–9), 781–801. doi: https://doi.org/10.1080/1351847X.2014.917119.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, *58*(2), 277. doi: https://doi.org/10.2307/2297968.

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, *68*(1), 29–51. doi: https://doi.org/10.1016/0304-4076(94)01642-D.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, *87*(1), 115–143. doi: https://doi.org/10.1016/S0304-4076(98)00009-8.

Brennan, M., Henrycao, H., Strong, N., & Xu, X. (2005). The dynamics of international equity market expectations. *Journal of Financial Economics*, *77*(2), 257–288. doi: https://doi.org/10.1016/j.jfineco.2004.06.008.

Buchuk, D., Larrain, B., Muñoz, F., & Urzúa, I. F. (2014). The internal capital markets of business groups: Evidence from intra-group loans. *Journal of Financial Economics*, *112*(2), 190–212. doi: https://doi.org/10.1016/j.jfineco.2014.01.003.

Busch, D. (2016). MiFID II: Regulating high frequency trading, other forms of algorithmic trading and direct electronic market access. *Law and Financial Markets Review*, *10*(2), 72–82. https://doi.org/10.1080/17521440.2016.1200333

Van Dijk, B. (2020). *Orbis*. https://orbis.bvdinfo.com/

Carson, E., Fargher, N. L., Geiger, M. A., Lennox, C. S., Raghunandan, K., & Willekens, M. (2013). Audit reporting for going-concern uncertainty: A research synthesis. *Auditing*, *32*(SUPPL.1), 353–384. doi: https://doi.org/10.2308/ajpt-50324.

Chlistalla, M. (2011). High-frequency trading. Better that its reputation? *Deutsche Bank Research*.

Conrad, J., Wahal, S., & Xiang, J. (2015). High-frequency quoting, trading, and the efficiency of prices. *Journal of Financial Economics*, *116*(2), 271–291. doi: https://doi.org/10.1016/j.jfineco.2015.02.008.

Dahlquist, M., & Robertsson, G. (2004). A note on foreigners' trading and price effects across firms. *Journal of Banking & Finance*, *28*(3), 615–632. doi: https://doi.org/10.1016/S0378-4266(03)00036-0.

Diaz-Rainey, I., & Ibikunle, G. (2012). A taxonomy of the "dark side" of financial innovation: The cases of high frequency trading and exchange traded funds. *International Journal of Entrepreneurship and Innovation Management*, *16*(1–2), 51–72. doi: https://doi.org/10.1504/IJEIM.2012.050443.

Essendorfer, S., Diaz-Rainey, I., & Falta, M. (2015). Creative destruction in wall Street's technological arms race: Evidence from patent data. *Technological Forecasting and Social Change*, *99*, 300–316. doi: https://doi.org/10.1016/j.techfore.2014.11.012.

Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*, *33*(1), 3–56. doi: https://doi.org/10.1016/0304-405X(93)90023-5.

Fičura, M. (2019). Profitability of trading in the direction of asset price jumps - analysis of multiple assets and frequencies. *Prague Economic Papers*, *28*(4), 385–401. doi: https://doi.org/10.18267/j.pep.703.

Francioni, R., Schwartz, R. A., Byrne, J., & Welkoborsky, S. (2017). Equity markets in transition the value chain, price discovery, regulation, and beyond. *Equity Markets in Transition: The Value Chain, Price Discovery, Regulation, and Beyond*, 1–611. https://doi.org/10.1007/978-3-319-45848-9

Frino, A., Garcia, M., & Zhou, Z. (2020). Impact of algorithmic trading on speed of adjustment to new information: Evidence from interest rate derivatives. *Journal of Futures Markets*, *40*(5), 749–760. doi: https://doi.org/10.1002/fut.22104.

Gong, Y., Chen, Q., & Liang, J. (2018). A mixed data sampling copula model for the return-liquidity dependence in stock index futures markets. *Economic Modelling*, *68*(April 2017), 586–598. doi: https://doi.org/10.1016/j.econmod.2017.03.023.

Halling, M., Pagano, M., Randl, O., & Zechner, J. (2007). Where is the market? Evidence from cross-listings in the United States. *Review of Financial Studies*, *21*(2), 725–761. doi: https://doi.org/10.1093/rfs/hhm066.

Hau, H. (2001). Location matters: An examination of trading profits. *The Journal of Finance*, *56*(5), 1959–1983. doi: https://doi.org/10.1111/0022-1082.00396.

Ibikunle, G. (2018). Trading places: Price leadership and the competition for order flow. *Journal of Empirical Finance*, *49*, 178–200. doi: https://doi.org/10.1016/j.jempfin.2018.09.007.

Ivarsson, I., Alvstam, C., & Vahlne, J. E. (2017). Global technology development by colocating R&D and manufacturing: The case of Swedish manufacturing MNEs. *Industrial and Corporate Change*, *26*(1), 149–168. doi: https://doi.org/10.1093/icc/dtw018.

Korajczyk, R. A., & Murphy, D. (2019). High-frequency market making to large institutional trades. *Review of Financial Studies*, *32*(3), 1034–1067. doi: https://doi.org/10.1093/rfs/hhy079.

Kudic, M., Pyka, A., & Sunder, M. (2016). The formation of R&D cooperation ties: An event history analysis for German laser source manufacturers. *Industrial and Corporate Change*, *25*(4), 649–670. doi: https://doi.org/10.1093/icc/dtv047.

Labadie, M., & Lehalle, C.-A. (2010). *Optimal algorithmic trading and market microstructure* (Issue September).

Lenczewski-Martins, C. J. (2017). *Handel o wysokiej częstotliwości na rynku walutowym*. Difin.

MacKenzie, D., Hardie, I., Rommerskirchen, C., & van der Heide, A. (2020). Why hasn't high-frequency trading swept the board? Shares, sovereign bonds and the politics of market structure. *Review of International Political Economy*, 1–25. doi: https://doi.org/10.1080/09692290.2020.1743340.

Marszk, A., Lechman, E., & Kato, Y. (2019). *The emergence of ETFs in Asia-Pacific*. Springer International Publishing. doi: https://doi.org/10.1007/978-3-030-12752-7.

Meyer, D. R., & Guernsey, G. (2017). Hong Kong and Singapore exchanges confront high frequency trading. *Asia Pacific Business Review*, *23*(1), 63–89. doi: https://doi.org/10.1080/13602381.2016.1157927.

Mishkin, F. S. (2000). *The economics of money, Banking, and financial markets* (6th ed.). Addison-Wesley series in economics. http://books.google.pl/books?id=1BBmPgAACAAJ.

Portes, R., & Rey, H. (2005). The determinants of cross-border equity flows. *Journal of International Economics*, *65*(2), 269–296. doi: https://doi.org/10.1016/j.jinteco.2004.05.002.

R Core Team. (2018). *R: A language and environment for statistical computing*. Foundation for Statistical Computing. http://www.r-project.org.

Raddant, M., & Wagner, F. (2017). Transitions in the stock markets of the US, UK and Germany. *Quantitative Finance*, *17*(2), 289–297. doi: https://doi.org/10.1080/14697688.2016.1183812.

Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in stata. *The Stata Journal*, *1*, 86–136.

Roqueiro, C. A., Guagliano, C., Guillaumie, C., Nauhaus, S., Winkler, C., & Kern, S. (2016). Order duplication and liquidity measurement in EU equity markets. *ESMA Economic Report*, *1*, 1–38.

Shkilko, A., & Sokolov, K. (2020). Every cloud has a silver lining: Fast trading, microwave connectivity, and trading costs. *The Journal of Finance*. doi: https://doi.org/10.1111/jofi.12969.

Staszkiewicz, L., & Staszkiewicz, P. (2015). HFT's potential of investment companies. *Prace Naukowe Uniwersytetu Ekonomicznego We Wrocławiu*, *381*, 376–389. doi: https://doi.org/10.15611/pn.2015.381.28.

Staszkiewicz, P. (2015a). High frequency trading readiness in Central Europe. *GSTF Journal on Business Review*, *4*(2), 61–67. doi: https://doi.org/10.5176/2010-4804_4.2.371.

Staszkiewicz, P. (2015b). How far is enough for financial markets? *5th Annual International Conference on Accounting and Finance (AF 2015)*, 21–26. doi: https://doi.org/10.5176/2251-1997_AF15.61.

Staszkiewicz, P. (2019). The application of citation count regression to identify important papers in the literature on non-audit fees. *Managerial Auditing Journal*, *34*(1), 96–115. doi: https://doi.org/10.1108/MAJ-05-2017-1552.

StataCorp. (2020). *Statistical Software: Release 16.0* (No. 16). Stata Corporation.

Tabuchi, T. (2019). Do the rich and poor colocate in large cities? *Journal of Urban Economics*, *113*. doi: https://doi.org/10.1016/j.jue.2019.103186.

Teixeira, J. C. A., Silva, F. J. F., Fernandes, A. V., & Alves, A. C. G. (2014). Banks' capital, regulation and the financial crisis. *The North American Journal of Economics and Finance*, *28*, 33–58. doi: https://doi.org/10.1016/j.najef.2014.01.002.

Upson, J., & Van Ness, R. A. (2017). Multiple markets, algorithmic trading, and market liquidity. *Journal of Financial Markets*, *32*, 49–68. doi: https://doi.org/10.1016/j.finmar.2016.05.004.

Van Kervel, V., & Menkveld, A. J. (2019). High-frequency trading around large institutional orders. *Journal of Finance*, *74*(3), 1091–1137. doi: https://doi.org/10.1111/jofi.12759.

Watkins, J. (2014). Regulating HFT "No Easy Task", Says FCA's Wheatley. *Euromoney Institutional Investor*, *June 5*.

Weller, B. M. (2018). Does algorithmic trading reduce information acquisition? *The Review of Financial Studies*, *31*(6), 2184–2226. doi: https://doi.org/10.1093/rfs/hhx137.

Wurgler, J. (2000). Financial markets and the allocation of capital. *Journal of Financial Economics 58*, 87–214. doi: https://doi.org/10.1093/brain/117.1.117.

Zubcsek, P. P., Katona, Z., & Sarvary, M. (2017). Predicting mobile advertising response using consumer colocation networks. *Journal of Marketing*, *81*(4), 109–126. doi: https://doi.org/10.1509/jm.15.0215.

Appendix 1

Reference entity	*Nick*
Wiener Börse AG	A_WB
Euronext Brussels SA/NV	B_EB
Българска Фондова Борса — София АД (Bulgarian Stock Exchange — Sofia JSCo)	BL_BSE
Cyprus Stock Exchange	C_CSE
Prague Stock Exchange	CZ_PSE
Copenhagen Stock Exchange AS	D_CSE
NASDAQ OMX Tallinn AS (NASDAQ OMX Tallinn Ltd.) (Estonia)	E_NASDAQ
NASDAQ OMX Helsinki Oy (NASDAQ OMX Helsinki Ltd.)	F_NASDAQ
Euronext Paris	FR_EURO
Deutsche Börse AG	D_DB
Athens Exchange	G_AE
Budapesti Értéktőzsde Zrt. (Budapest Stock Exchange	H_BSE
Irish Stock Exchange Ltd	IR_ISE
Borsa Italiana SpA	I_BI
JSC NASDAQ OMX Riga	LA_NASDAQ
Nasdaq OMX Vilnius	LI_NASDAQ
Société de la Bourse de Luxembourg SA	LUX_SBL
Malta Stock Exchange	M_MSE
NYSE Euronext (International) BV, NYSE Euronext (Holding) BV, Euronext NV, en Euronext Amsterdam NV	NL_NYSE
Giełda Papierów Wartościowych w Warszawie SA (Warsaw Stock Exchange)	PL_WSE
Euronext Lisbon — Sociedade Gestora de Mercados Regulamentados, SA	PO_ERONEXT
S.C. Bursa de Valori București SA (Bucharest Stock Exchange SA)	RO_BSE
Bratislava Stock Exchange	SK_BSE
Ljubljana Stock Exchange (Ljubljanska borza)	SO_LSE
Soc. Rectora de la Bolsa de Valores de Madrid SA	ESP_BVB
NASDAQ OMX Stockholm AB	SW_ NASDAQ
LIFFE Administration and Management	UK_LIFFE
The London Metal Exchange Limited	UK_LME
ICE Futures Europe	UK_ICE
Nasdaq OMX Iceland hf.	IR_NASDAQ
Oslo Børs ASA	NOR_OB

Source: own presentation.