

PRACE NAUKOWE

Uniwersytetu Ekonomicznego we Wrocławiu

RESEARCH PAPERS

of Wrocław University of Economics

Nr 381

Financial Investments and Insurance – Global Trends and the Polish Market

edited by
Krzysztof Jajuga
Wanda Ronka-Chmielowiec



Publishing House of Wrocław University of Economics
Wrocław 2015

Copy-editing: Agnieszka Flasińska

Layout: Barbara Łopusiewicz

Proof-reading: Barbara Cibis

Typesetting: Małgorzata Czupryńska

Cover design: Beata Dębska

Information on submitting and reviewing papers is available on the Publishing House's website
www.pracnaukowe.ue.wroc.pl
www.wydawnictwo.ue.wroc.pl

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Wrocław 2015

ISSN 1899-3192
e-ISSN 2392-0041

ISBN 978-83-7695-463-9

The original version: printed

Publication may be ordered in Publishing House
tel./fax 71 36-80-602; e-mail: econbook@ue.wroc.pl
www.ksiegarnia.ue.wroc.pl

Printing: TOTEM

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HFT'S POTENTIAL OF INVESTMENT COMPANIES

Summary: On Polish broker-dealers market 1908 investment-related entities and six registered exchange markets operate. High frequency trading (HFT) is a form of algorithmic trading based on massive orders executions. One of the key success parameters of HFT is the distance between the exchange and stock member mainframe. Based on the data from the Polish Financial Supervisory Authority licensing registers and geocoding data we computed the distances between the investment related entities and exchanges. We analyzed their geographical presence in terms of types of entities and their region of origin. We found out that out of 1908 participants six have substantial HFT's competition advantage on Warsaw Stock Exchange. The substantial tendency for HFTs among the external stock exchanges is with the commodity market. The potential development of the Polish HFTs is likely to be significantly concentrated.

Keywords: algorithmic trading, high volume trading, WSE, focus, brokerage house.

DOI: 10.15611/pn.2015.381.28

*A robot may not harm humanity, or, by
inaction, allow humanity to come to harm.*

Isaac Asimov

1. Introduction

At present, the trading of financial instruments has increasingly been carried out in an automated fashion. Algorithmic trading (AT) uses a range of tools from an algorithm to feed portions of an order into the market at pre-set intervals in order to minimize market impact cost, to many algorithms that are able to assimilate

information from multiple markets in different assets and to use this to implement a high-speed, multi-asset trading strategy that closes numerous inter-related trades in fractions of a second [IOSCO 2011, p. 10].

High-frequency trading (HFT) is a type of algorithmic trading. HFT applies sophisticated technological tools and computer algorithms to rapidly trade securities. Algorithmic trading may be used in any investment strategy, including market making, inter-market spreading, arbitrage or pure speculation.

The use of HFT on developed markets is significant. As of 2009 the high-frequency trading firms, which represented approximately 2% of about 20,000 trading firms operating in the U.S. markets, accounted for 73% of all U.S. equity trading volume [Iati 2010; Motylska-Kuźma 2012; Zieliński 2012]. As of 15 April 2013 the Warsaw Stock Exchange (WSE) put into operation a new transaction system UTP (Universal Trading Platform) licensed from NYSE. The UTP replaced the Warset transaction system. In contrast to Warset, UTP is compatible with NYSE Euronext stocks. UTP is generally quicker and scalable. It offers 20 thousands orders execution per seconds, with 150 milliseconds speed. These technical parameters open the gate for the algorithmic trading development. After the introduction of UTP to the WSE, the number of executed orders raised on average by 17%, even more by 40% raised the number of the placed orders [Kobza 2013].

The purpose of the paper is to challenge the impact of the HFT's on the WSE development.

We hypothesized that the implementation of UTP itself has enhanced the WSE interconnectivity. By geocoding the financial institutions notified on the market, we were able to judge upon the distances towards financial markets. Following Hau's [2001] research we concluded on the actual HFT's potential on the market players.

We aim, as well, to rearrange the current world-wide algorithmic trading literature to show the variety of issues and challenges facing the market participants and supervisors. We demonstrate that the HFT's development is constrained by entities origin. According to the authors' knowledge, this is the only paper that addresses the HFT's microstructure of the Polish registered entities market.

2. Literature review

We identified more than 600 papers published in leading journals relating to the algorithmic and high frequency trading. We do not attempt to provide a comprehensive review on this discussion, rather a sketch on issues presented that relate to our research. Scientific research on the HFT evolves into a few areas:

- general discussion on the HFT impact on market,
- financial aspects of the HFT,
- econometric considerations,
- ethics,

- forecasting,
- international aspects,
- technological aspects,
- miscellaneous.

The industry generally claims that high-frequency trading substantially improves market liquidity, narrows bid-offer spread, lowers volatility and makes trading and investing cheaper for other market participants. This aspect tends to be confirmed by the general stream opinions. Hendershott, Jones and Menkveld [2011] confirmed that the HFT improves the liquidity and enhances the access to information on quotes. Improvements of overall market quality, including bid-ask spreads, liquidity, and transitory price impacts, were observed by R. Litzenberger, Castura and Gorelick [2012]. Manahov with his team found evidence that the HFT enhances the efficiency of prices and plays a positive role in the price discovery process [Manahov, Hudson, Gebka 2014]. Easley, de Prado and O'Hara [2012] argue that speed is not the defining characteristics that define high-frequency trading. It is characterized by strategic decisions made in a volume-clock metric. Even if the speed advantage disappears, HFT will evolve to continue exploiting structural weaknesses of low-frequency trading (LFT). HFT is given as an example of fission risk [Adamska 2013] where computer takes action, while the linked person (account owner) accounts for results. The HFT involves the risk of the structure [Staszkiwicz 2011] while the computer generated transactions are difficult to be recognized as the related parties' transactions. The algorithmic risk of error itself is not a heavily explored area contrary to the company risk [Kuziak 2011].

Research on the professional traders geographical distribution shows that traders located outside home country of the market and in foreign cities show lower proprietary trading profit. Evidence was found for an information advantage due to corporate headquarters proximity for high-frequency trading [Hau 2001]. The HFT does not constitute a homogenous set of strategies, there are different trading strategies within HFT which differ in terms of popularity and efficiency [Hagströmer, Nordén 2013]. The time lag between the tick for equity and index quoting has impact on the correlation analysis, thus both variables should be refreshed on similar time scale [Kenett et al. 2013].

In the area of econometrics the attention was paid to optimal sampling of high-frequency return data for the purpose of realized variance/covariance estimations. Bandi and Russell [2008] show that the gains yielded by optimal sampling are economically large, statistically significant and robust to realistic transaction costs. An irregular supply interval of data constituted a technical issue for variances estimation and resulted in discussion on the autoregressive conditional duration (ACD) models [Engle, Russell 1998; Engle 2000]. There are wide research needs for more efficient estimators [Bannouh, van Dijk, Martens 2009], return variance structure [Bandi, Russell 2006], stochastic variability for return and time [Scalas

et al. 2004] or interpolation of the inequity in the non-synchronized time series [Precup, Iori 2007].

Researchers indicate that increasing application of the HFT opens new way for business misconduct which should be balanced with promotion of ethical behavior. Davis and co-authors showed that automation of the processes leads to cross-disciplinary ethics arbitrage, thus the organization should assume “wide responsibilities to external market participants and society” [Davis, Kumiega, Van Vliet 2013]. Imposed market regulation and supervisory gaps allowed fast traders to earn substantial revenue at the expense of slow traders [McInish, Upson 2013]; on the other hand, Hasbrouck and Saar claim that increased low-latency activity does not always lead to the detriment of long-term investors [Hasbrouck, Saar 2013]. Nevertheless the increase of HFT trading and ordinary trading have impact on the operational risk measurement allocation and monitoring for brokers themselves [Chomiak-Orsa, Staszkievicz 2014].

Another intersection of interests is the research on the relationship between the efficacy of intervention operations and the “state of the market” at the moment the central bank operation is made public.

The application of high-frequency intra-daily data indicates that traders typically know that the FED is intervening at least 1 h prior to the public release of the information in newswire [Dominguez 2003]. Contrary Neely states that the central bank intervention does not generate technical trading rule profits even if the high frequency data are applied [Neely 2002].

Application of a machine learning method for HFT outperforms technical analysis typically recommended by practitioners. Overconfident investors tend to perceive themselves to be more competent and thus are more willing to act on their beliefs, leading to higher trading frequency [Graham, Harvey, Huang 2009].

The above discussion indicates that the HFT is none directly observed variable, thus the proxy is used for its estimation. Some researchers have used the messages traffic but other authors focused on the internal proxy of the HFT. There is little proxy with the distances applied until now. The research does not necessarily focus on the geographical concentration aspects. The preliminary review indicates as well that not all companies will be equally equipped for the HFT, especially because of the technological, know-how, and physical condition. The last observation relates directly to the goal of our research. We hypothesized that:

H₀: UTP implantation enhanced the WSE international interconnectivity.

3. Methodology

The approximation of distance between any two different locations A (Long1, Lat1) and B (Long2, Lat2), where Long1 and Long2 are longitudes, Lat1 and Lat2 – latitudes, was calculated based on the following formula:

$$d = 2 \times \pi \times q \times R/360,$$

where:

$$\pi = 3.1415\dots,$$

$R = 6371\text{km}$ (average radius of the Earth).

q – the solid angle between the points A and B.

Because

$$\cos(q) = \sin(\text{Lat1}) \times \sin(\text{Lat2}) + \cos(\text{Lat1}) \times \cos(\text{Lat2}) \times \cos(\text{Long1} - \text{Long2}),$$

thus

$$d = 2 \times \pi \times \arccos(\sin(\text{Lat1}) \times \sin(\text{Lat2}) + \cos(\text{Lat1}) \times \cos(\text{Lat2}) \times \cos(\text{Long1} - \text{Long2})) \times R/360.$$

An uniformed Earth radius used due to its changeability within 0–90 degrees, while the latitude changes with the sample from around 40 to 60 degrees, thus potential corrections are insignificant to conclusions. The Earth is a rotation geoid thus there is no universal method for distance measurements, however, the different matrix has minor impact to final conclusions. The geocoding points were derived based on WGS-84/GPS. The geocoding was extracted partly automatically and partly manually.

Co-location services exist to house trading systems used by market participants (and potentially other parties, such as data vendors) in a location close to trading venue servers. Such services are generally provided by a trading venue, whether within its data centre or in a location of close physical proximity. The latency is the delay between a trading decision and the resulting trade execution. The potential of HFT was attributed to the co-location, latency and real timing. The real timing is the sum of the time of a mainframe connection with end-user and the time for human intervention (monitoring of execution server). The distance was applied as potential proxy. The competitive advantage was recognized with entities up to 1 km distance to capital market, while the uniformity was assumed for the entities located more than 5 km from the mainframe. Consistency with the distances and manual geocoding was ascertained both with a manual check and F testing of variances against location. For geocoding of the foreign entities operating on the Polish territory with the representative office, the longitude and latitude was assigned to the Polish representative and to the parent company separately. We did not consider, in this research, the related parties of financial groups and conglomerates nor the subordinate entities (parent, subsidiaries, associated). The uniformity of ticks (the minimum price movement by which an instrument's price can move) was assumed according to the UTP parameters.

4. Data set

The entities' data were collected from the official web side of Polish Financial Supervision Authority (PFSA) as of 10 March 2014. The membership of the WSE was extracted from the Giełda Papierów Wartościowych w Warszawie (Warsaw Stock Exchange) official web site. All geocoding data, if necessary, were retranslated from the degrees, minutes, seconds into decimal degree. The geocoding of the addresses was done using the application of the batch transferring at www.findlatitude-andlongitude.com. The output data were reviewed for consistency and manual corrections were made for the missing coding. For consistency check, the F test was imposed over the distances to the stocks. The calculation was performed using the application of the R environment [R Core Team 2013].

5. Results and discussion

Composition of market participants by the types of the entities is shown in Table 1.

Table 1. Types of participants and its frequency

Type	Numbers	Share (%)
Without branch notifications	1776	93.08
Broker-dealers houses domiciled in Poland	55	2.88
Polish entities notified abroad without branches	34	1.78
Banks licensed for investment activities	14	0.73
Polish entities notified aboard with branches	10	0.52
Notifications with branches	9	0.47
Parent companies of branches notified	9	0.47
Commodity houses domiciled in Poland	1	0.05
All entities (investment companies)	1908	100
Stocks exchanges	6	0.31

Source: own calculation and presentation based on PFSA registers.

The majority of the market participants are the foreign entities (domiciled in Europe) which operate from their countries of origin without building a trading infrastructure on the Polish territory. The overrepresentation of the European entities is attributable to general EU financial passport rules. The notified without branches companies are rather unlikely to perform the HFT on WSE. The distribution demonstrates the geographical impact on the Polish market. The majority of offshore market participants are located in the UK, Cyprus and the Netherlands as shown in

Figure 1 and Table 2. Cyprus and the Netherlands locations are rather linked to the tax management while the UK locations to capital management projects. There are instances of notification of an entity located in USA.



Figure 1. Geographical allocation of the entities notified on the Polish territory

Source: own study.

On the Polish territory there are no participants from Russia, Asia, Africa, South America and Australia. However, the analysis takes into account only direct place of operation. There are no provisions taken for any capital commitments and/or control. The number of participants according to the country of origin is shown in Table 2.

Table 2. Distribution of market participant by countries

State	Number of entities
The United Kingdom	1443
Cyprus	116
Poland	80
The Netherlands	36
Ireland	26
Germany	24
France	24
Luxemburg	18
Norway	16
Austria	15
Czech Republic	14
Others	96
Total	1908

Source: own calculations.

Out of seven states, in the direct neighborhood of Poland, only two of them, Germany and Czech Republic, have direct representation on the Polish market. The representation structure is replicated to the notification of the stock exchanges activities. There six stock exchanges allowed to operate on or from the Polish territory are: London International Financial Futures and Options Exchange (LIFE), London Metal Exchange (LME), Intercontinental Exchange Futures Europe (ICE), Vienna Stock Exchange (VSE), Budapest Stock Exchange (BSE) and home stock: Warsaw Stock Exchange (WSE). The distances between stock exchanges in km are shown in Table 3.

Table 3. Distances in between stock exchanges (in km)

	LME	LIFE	ICE	VSE	BSE	WSE
LME	0	1	1	1232	1448	1446
LIFE		0	1	1233	1448	1447
ICE			0	1232	1447	1446
VSE				0	216	556
BSE					0	543
WSE						0

Source: own study.

Generally LME, LIFE and ICE are concentrated, with distance between them less than one kilometer. The VSE and BSE are grouped together, while WSE builds up an isolated point. Distance testing for elimination of the errors in the data sources (at confidential level), as data *geocoding* were provided manually. Table 4 shows the tests for variance equality between the specific stock exchanges. We applied *F* test to testify the integrity of data due to the manual geocoding. We hypothesized that the companies' average distances to specific stocks will follow similar path of variances against each of the stock.

Table 4. Testing for equality of the variances *F* test (in brackets *p*-values)

	WSE	BSE	VSE	LIFE	ICE	LME
WSE	X	1.122 (.01)	1.099 (.04)	2.421 (.00)	0.413 (.00)	0.413 (.00)
BSE		x	0.980 (.65)	2.715 (.00)	2.712 (.00)	2.713 (.00)
VSE			x	2.661 (.00)	2.658 (.00)	2.659 (.00)
LIFE				x	1.001 (.98)	0.999 (.98)
ICE					x	1.000 (.99)
LME						x

Source: own study.

The results do not give the evidence to judge that the data are systematically inconsistent. The distances distribution of all participants towards the respective capital market is provided in Figure 2.

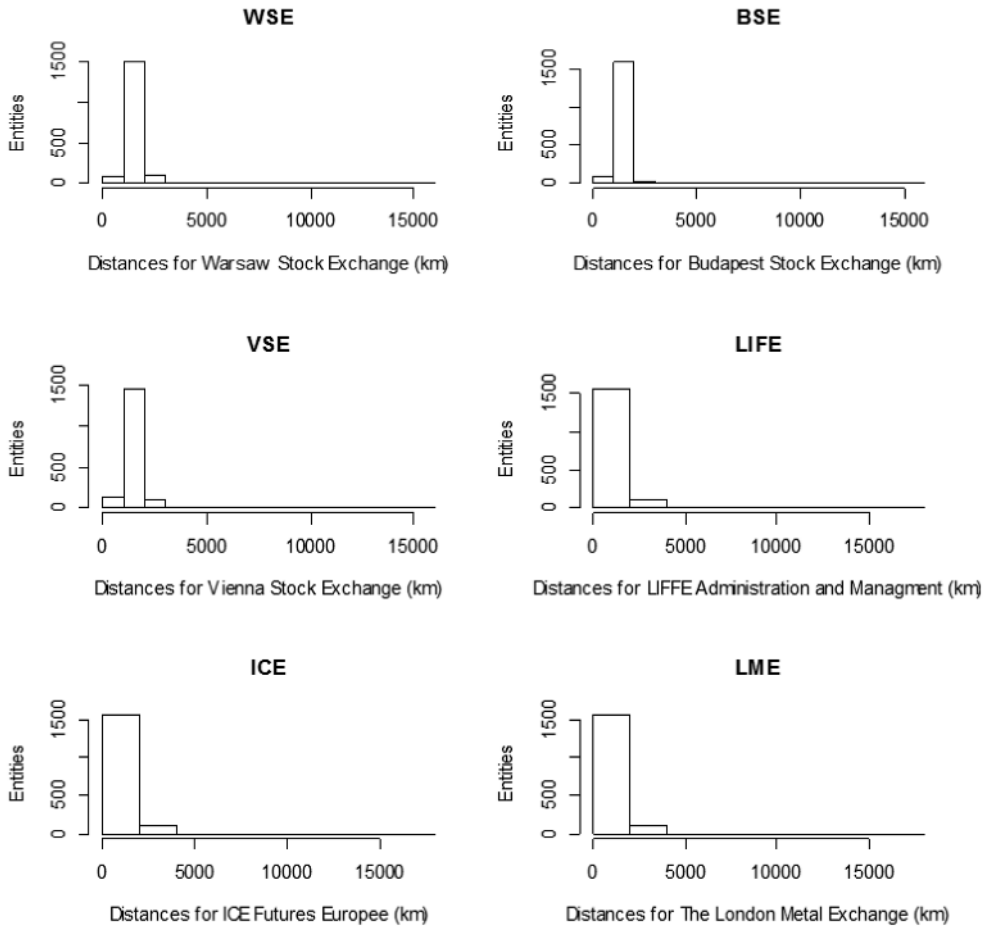


Figure 2. Distribution of distances to the stock exchanges

Source: own calculation and presentation.

The empirical density, after close examination of 0 to 5000 km interval, has two peak characteristic of all markets. Peaks denote the entities domiciled in the UK, Poland and Cyprus, and density composition depends on the market analyzed. The maximum distance is observed for the entity notified from the USA. The majority of the companies are in a distance within five thousand of kilometers from the stock exchange. The HFT’s ability increases with the decrease of the distance to the capital

market mainframe. The numbers of entities within the distance from 50 m to 5 km are shown in the table 5.

Table 5. Number of entities with selected distances to exchange

Distance	WSE	BSE	VSE	LIFE	ICE	LME
Up to 50 m	0	0	0	0	0	1
Up to 300 m	1	0	3	27	5	49
Up to 500 m	3	0	5	94	14	97
Up to 1 km	9	0	11	302	86	302
Up to 3 km	49	1	11	521	435	459
Up to 5 km	55	3	12	1004	844	941

Source: own study.

Based on the data, the highest HFT's ability shows LME. The tendency towards metal exchange might be attributed to the fact that Poland is a world-wide cuprum exporter (KGHM) and that the commodity exchanges are not significantly developed on the Polish territory. The supremacy of the UK based market for its HTS' potential is to some extent not intuitional observation. Surprisingly the WSE is placed after all UK based exchanges and Vienna Stock Exchange when taking into consideration number of the entities within up to 500 m from the capital market. On longer distances the WSE overtakes VSE. The HFT is unlikely to be used for pure Polish entities. The HTS' ability is strongly related to the distance to mainframe. The cut-off point was set as 1 km to capital mainframe, where the distance may be assumed to create a competition advantage over the rest of the entities. We followed the Garvey and Wu's observation that "traders located in the NYC area execute their market orders at a price, on average, 1.8 cents worse than the quoted price they observe at order submission time [...]. Traders located outside of the NYC area execute their market orders at a price 4.1 cents worse. The price differentials result in financial center traders experiencing a total latency cost of \$2,288,716 on 504 million executed shares, whereas more distant traders experience a total latency cost of \$3,017,089 on 220 million executed shares" [Garvey, Wu 2010, p. 370].

The specific list of the companies within 1 km from WSE is shown in Table 6.

Not all of these entities have the license for the orders execution. Consequently three out of nine are unable to operate on HFT due to the lack of license and stock membership. There are no foreign notified entities on the list, thus the competition advantage lies solely with Polish domiciled companies or banks. Those are well equipped with capital and represent usually a relatively stable market with capital requirements [Staszkiwicz 2013a, b; Kasiewicz, Kurkliński 2013]. Among the entities listed as close to WSE are only broker-dealer houses (four eligible) and two

bank branches licensed for capital market operations. Consequently 0.3% of all market participants have a HFT competitive advantage. Thus taking into account the increase of the trading volume as reported by Kobza, the market is likely to be strongly concentrated. It will probably be concentrated, in future, around small fraction of the locally domiciled companies. This observation is in line with Hau's results [Hau 2001].

Table 6. Entities within 1 km distance to WSE

Entity name	Member	Execution	Type*	WSE distance (km)
PGE Dom Maklerski SA	Yes	Yes	BD	0.254
BGŻ SA Biuro Maklerskie BGŻ SA	Yes	Yes	BPDM	0.342
IFM Global Asset Management Sp. z o.o.	No	No	BD	0.436
Raiffeisen Bank Polska SA Dom Maklerski	Yes	Yes	BPDM	0.755
NWAI Dom Maklerski SA	Yes	Yes	BD	0.790
Dom Maklerski Banku Ochrony Środowiska SA	Yes	Yes	BD	0.841
Dom Maklerski mBanku SA	Yes	Yes	BD	0.871
Tullet Prebon (Polska) SA	No	No	BD	0.871
ING Investment Management (Polska) SA	No	No	BD	0.975

* BD – Broker-dealer, BPDM – bank office broker-dealer.

Source: own calculations, membership data based on the WSE register.

Due to the potential numbers of the entities with HFT's competitive advantage we reject our null hypothesis that

H₀: UTP implantation enhanced the WSE international interconnectivity in favor of the statement that UTP implantation did not enhance the WSE international interconnectivity.

The relatively small impact of the HFT on Polish territory might be explained both by development of the infrastructure and by investor perceptions. HFT algorithms do not explicitly take into account the intrinsic value of an investment. Those algorithms are only concerned about what happens to the price in the next few seconds. This short term approach limits the social benefits of HFT. Low frequency investors are cautious about the possibility of having their traders detected and headed off by high frequency traders. This is the reason why traditional investors allocate their orders in "dark pools" [Manahov, Hudson, Gebka 2014].

In this study we did not consider the related parties of financial groups and conglomerates such as subordinates entities (parent, subsidiaries, associated). Our study abstracts from the potential shadow brokerage process and HFT procedures

applied on the four levels of broker-dealers internet platforms or more generally on relation between the HFTs risk and broker value. A continuance of Kasiewicz and Rogowski's research is likely to be informative in AT area [Kasiewicz, Rogowski 2006]. The architecture of these platforms is mainly based on the server-client applications, thus latency is on the data transmission between final clients and order matching server, which is conditioning upon distance and connection capacity. The application of the open access services for geocoding impacts the quality of data. It might have an effect on the final distribution of distances, however, its impact, we believe, is rather minor in terms of the conclusion derived. The main site proxy is different than the textual one, probably the application of the stock-internal data would result in different rankings of the entities. The magnitude of this potential discrepancy needs a tailored expensive study which is unfeasible to us at the moment. We abstract from the impact of the business continuity solution for hot and cool offsite as well as from the prevention architecture of the stock-exchanges servers. The potential avoiding of the latency by clustering the stock-member servers with the stock-exchange mainframe does not necessary sort out the server control and uploading issues thus clustering should rather replicate the biased side effect. Nevertheless, this fact is considered as an assumption of our methodology.

6. Conclusions

We observe different investment strategies across markets, some of them are based on research wisdom whereas others on the speed of data processing. Our research examines the interconnectivity driver of the HFT on Polish territory.

We gather empirical findings for potential concentration of the HFT in a small number of entities domiciled solely in Poland. There are only six companies with substantial HFT competitive advantage, which represents 0.4% of the total companies notified. The WSE is not the primary market with the HFT potential. The majority of presence is focused on the commodity not equity market.

Our empirical findings are one step towards better understanding of the underlying principles of HFT and its implications for market structure and performance, although given the complexity and importance of this area, much more research is needed. There are several interesting research directions to explore. For example, it would be interesting to use a comparison of the textual and distance proxy together to ascertain their interdependence.

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POTENCJAŁ HANDLU ALGORYTMICZNEGO FIRM INWESTYCYJNYCH

Streszczenie: Na polskim rynku firm inwestycyjnych funkcjonuje 1809 podmiotów oraz sześciu notyfikowanych organizatorów. Handel szybkich częstotliwości (HSC) jest formą handlu algorytmicznego opartą na dużej ilości i szybkości realizacji zleceń. Jednym z kluczowych parametrów sukcesu HSC jest odległość między serwerem brokera a serwerem centralnym giełdy. Na podstawie danych zgromadzonych z Komisji Nadzoru Finansowego, tj. licencji, adresu i zakresu, zostały obliczone odległości wszystkich funkcjonujących podmiotów względem rynku macierzystego i polskiego. Analizy dokonano pod względem typu podmiotu i rynku. Badanie daje podstawy do stwierdzenia, że z 1908 uczestników rynku tylko sześć podmiotów ma przewagę konkurencyjną w HSC na GPW. Badanie wskazuje na silny związek HSC z rynkiem towarowym. Potencjalny rozwój HSC w Polsce prawdopodobnie będzie silnie skoncentrowany.

Słowa kluczowe: handel alogrytmiczny, handel wysokich częstotliwości, GPW, koncentracja, dom maklerski.