HIGH-FREQUENCY TRADING AND ITS ROLE IN FRAGMENTED MARKETS

Complete Research

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Abstract

The financial services industry is among the leading industries in IT-spending. Still, little research exists which investigates how IT influences the financial services sector. Against this background, we study how a technology which emerged within the last years affects securities trading: High-Frequency Trading (HFT). Hereby, we focus on HFT and its impact on market efficiency. On the basis of a long-term analysis, we find that HFT decreases price dispersion among two distant markets. Analyzing the introduction of the German HFT Act, we further observe that the price dispersion between two leading trading venues for German blue chip securities increased. We conclude that HFT increases market efficiency in the European market landscape by transmitting information between distant markets.

Keywords: Fragmentation, High-Frequency Trading, Market Efficiency, Securities Trading

1 Introduction

The economic value of IT has been subject to the scientific discussion for several decades (Barua, Kriebel, and Mukhopadhyay, 1995; Bharadwaj, 2000; Crowston and Treacy, 1986). As most of these studies focus on firm performance, i.e. profit (Lee, 2001) or productivity (Hitt and Brynjolfsson, 1996), effects of IT-systems on a whole industry are still under researched. One major reason is that measuring the IT-utilization in a single industry and in a timely manner is challenging. It can be expected that these effects can be observed at industries which exhibit a large portion of IT-spending measured against their overall revenue (IT-intensity). Among the leading industries regarding IT-intensity (6.2% of the revenue) is the financial services sector analyzed in our study (Dewan and Min, 1996; Gartner, 2014).

Automatization is not entirely new within the financial services sector, especially the securities trading industry has seen a tremendous development within the last several years. Hereby the securities trading industry was not only influenced by regulation but also by technological advancements. IT-innovations like Smart Order Routing (Ende, Gomber, and Lutat, 2009) or High-Frequency Trading (HFT, defined in section 2.2) emerged and further shaped the way securities trade today. The latter is especially subject to public and academic discussion (Kirilenko et al., 2014; Lattermann et al., 2012) as 24% - 43% of the European value traded is HFT-based (European Securities and Markets Authority, 2014). Against this background and against the prevailing discussion in IS-research we wonder whether IT in the form of HFT can create a positive spillover for the securities trading industry. We follow the call of Kohli and Grover (2008) by contributing to the 4^{th} research thrust "*What are the indirect and intangible paths to economic value that can be influenced by information and IT capabilities*". In this regard we want to increase the understanding of HFT on the securities trading industry.

Thereby we focus on the financial market, a market where the whole economy either directly (retail investors) or indirectly (banks, investment funds) takes part in. Financial markets should be as efficient as possible which is demonstrated by a large literature stream on the efficient-market hypothesis (Fama, 1970). In financial markets investors should be able to trade on prices which incorporate all information.

If this is not the case information asymmetries arise which can cause inefficient allocation of capital. However, as European equities markets are fragmented, price dispersions can occur among distant venues. We wonder whether HFT provides a positive spillover for the financial services industry by making markets efficient. On the basis of a dataset covering one year and containing French blue chips securities we find that increasing HFT-activity increases the market efficiency. To establish causality between market efficiency and HFT we extend our results by an event study of a recent regulatory event: the introduction of the German High-Frequency Trading Act. Hereby we give empirical evidence that the market efficiency lessens after the introduction of the act.

Our study contributes to the realm of (I) IS and (II) market microstructure research. In the case of (I) we analyze whether IT can create a positive spillover, i.e. a welfare increase for firms in the same industry not investing in IT firsthand. Further we contribute to the research stream on IT in financial markets, which predominantly focuses on exchange systems. In (II) we add to the literature stream on HFT and fragmentation by adding important evidence on the role of HFT in a fragmented market setting.

The remainder of the paper is structured as follows: in the succeeding section the related work is reviewed, further we discuss recent results and identify current research gaps. These remarks are followed by our research approach where our research hypotheses are defined along with an introduction of the key variables and the datasets. The next section depicts the results of our two empirical analyses: the long term study and short-term (event) study. Contributions and limitations are presented in the succeeding section. Within the last section concluding remarks are given.

2 Related Work

2.1 IT in financial markets

The importance of IT in financial markets is highlighted by an evolving literature stream within the IS-community. While most of the financial services literature analyzes the effect of IT on key performance indicators (e.g. see work of Berger (2003); Shu and Strassmann (2005)) the research stream on IT in financial markets dissects the effects on market quality and market efficiency. Market quality is defined by several dimensions, hereby researchers focus mostly on the price's waviness (volatility) and the liquidity (e.g. spread) (Harris, 2003). Market quality and efficiency are influenced by (I) market participants and the (II) the IT-systems used by the exchange.

(I) Focusing on market participants a small yet growing IS-literature stream analyzed the effects of automated traders in financial markets. Haferkorn, Zimmermann, and Siering (2013) evaluate the effect of IT-based trading on market quality. In their study they quantified IT-based trading with the Order-To-Trade Ratio (OTR) a measure commonly used in related literature. The OTR is further validated as a measure for algorithmic trading on the basis of a proprietary dataset. They find that IT-based trading reduces price uncertainty (measured by standard deviation of the MP and high/low ratio) thus increasing market quality. However, taking into consideration liquidity they were not able to draw a uniform picture. In this regard the work Zhang and Riordan (2011) adds nicely as they show on the basis of a proprietary dataset that HFT provides liquidity when the demand is high and take liquidity when the demand is low. Thus they conclude that HFT increases market quality.

(II) With the regard to IT-systems of exchanges (i.e. exchange systems) Wagner et al. (2010) find that an IT-update in 2007 at the biggest German Exchange increases price efficiency between the derivatives (future) and cash market. Studying the same event at Deutsche Boerse Riordan and Storkenmaier (2012) analyze the effect on market quality. They find that liquidity for small and medium-sized securities increased after the introduction of a new exchange system. Comparing a legacy system employed at Deutsche Boerse in 1997 against the system used in 2009 Zhang et al. (2011) further report that market quality (i.e. liquidity) has improved. Jain and McInish (2012) studied the effect of a new exchange system at the Tokyo Stock Exchange in 2010. In line with previous observations they also report evidence of increasing liquidity. It is important to note that most exchange system upgrades resulted in a reduction of the latency between traders and the exchange system. Thus, observations being made might also be attributed to a change in the behavior of traders rather than solely the new exchange system.

To conclude the literature stream of IT in financial markets it can be stated that positive effects of IT could be shown when used by market participants and after exchange systems were upgraded. Still current studies neglect the fragmented nature of modern securities markets, in particular the challenges arising from fragmentation. With this study we add further evidence in this area by analyzing effects of IT (i.e. HFT) used by market participants on the securities trading industry. Thereby we broaden the scientific scope to the fragmented nature of today's securities markets.

2.2 Literature on Economic Value of HFT & Fragmentation

Since the Flash Crash on the 6^{th} of May 2010 HFT has become quite prominent in the public, academic and regulatory discussion (Kirilenko et al., 2014; Lattermann et al., 2012). HFT is a part of algorithmic trading (AT) which is defined as *"the use of computer algorithms to automatically make trading decisions, submit orders, and manage those orders after submission"* (Hendershott, Jones, and Menkveld, 2011). While AT is mostly used to buy or sell a large position of securities without a market impact (Gomber and Gsell, 2006), HFT focuses on proprietary trading with a flat position at the end of the day. HFT exhibits a high trading volume and frequent order updates. It typically employs arbitrage, market making, liquidity detection and trend strategies (Gomber and Haferkorn, 2013; Menkveld, 2013). To assess the economic value of HFT, the financial market where HFT participates and its market quality is evaluated. Most studies suggest that HFT decreases volatility, thus being helpful to market quality as it dampens mispricing (Hagstroemer and Norden, 2013; Hasbrouck and Saar, 2013). Contrary to this Zhang (2010) finds that HFT-activity is positively correlated with volatility. Regarding the spread (difference between best bid and best offer) Hasbrouck and Saar (2013) could show a positive (decreasing) effect of HFT. Likewise this was shown for AT in general (Boehmer, Fong, and Wu, 2013; Hendershott, Jones, and Menkveld, 2011). These results are in line with an event study conducted by Malinova, Park, and Riordan (2013) who observe an increase of the spread due to a message-limit aimed at reducing HFT-activity in Canada. Similar effects were discovered by Friederich and Payne (2015) who show that limiting HFT-activity trading, by introducing an OTR limit, decreased the liquidity (i.e. quoted depth) in the Italian securities market.

The price efficiency is a measure for the informativeness of the prices. Regarding the semi-strong efficient-market hypothesis of Fama (1970) all information should be instantly incorporated in the price. This is necessary to ensure an efficient allocation of capital. Against this background how HFT influences price efficiency is of high importance. Brogaard, Hendershott, and Riordan (2014) study the effect of HFT on price efficiency and find that HFT increases price efficiency by trading against the opposite direction of pricing errors. These results are further confirmed by an empirical study by Carrion (2013). However opposite results could be also shown by Zhang (2010) who warns that HFT might be harmful as he finds that HFT decreases price efficiency.

Our research contributes to the growing literature body on fragmentation (Gomber et al., 2013). Fragmentation in Europe has started with the liberalization of equities markets introduced with MiFID I (European Parliament, 2004). Since the introduction of MiFID I securities can be traded at several venues located in Europe independently from their homemarket which led to a fragmented market landscape (Fidessa, 2014). Again academia takes market quality into consideration, thereby it was found that fragmentation in Europe leads to an overall improvement of liquidity (Chlistalla and Lutat, 2011; Degryse, Jong, and Kervel, 2011; Foucault and Menkveld, 2008; Gomber, Gsell, and Lutat, 2010). Considering price discovery (how information is processed into prices) Storkenmaier, Wagener, and Weinhardt (2012) conclude that information is asymmetrically processed at different markets. Further they show that information affects fragmentation.

The large literature body on HFT and fragmentation shows the growing interest of academia and the practical importance of these two topics. Regarding HFT, no final conclusion has yet been drawn as results from different studies deviate. These deviations might be explained by different datasets (public vs. proprietary dataset) used and the heterogeneity of strategies employed by HFT. Taking fragmentation into consideration it has been shown that the competition among trading venues attracts more liquidity, however at the same time liquidity is now located at different venues which leads to fragmented liquidity and pricing. The latter one is especially critical as investors need to be able to trade on fully incorporated prices, independent from their trading venue. With our research we want to evaluate whether HFT can provide a positive effect on securities trading by reducing fragmented pricing.

3 Research Approach

3.1 Research Hypothesis

In this study we analyze whether IT can cause a positive spillover on investors and financial services firms which are not investing in IT firsthand. We conduct our investigation on an industry which exhibits the 2^{nd} highest IT-intensity (6.3% of the revenue): the financial services industry (Gartner, 2014). In particular we evaluate whether IT-systems being used in security markets can help to transmit information between distant markets. With the regard to the efficient-market hypothesis of Fama (1970) the price of a good (in our case a security) should inhibit all information instantly. This is an important factor in a fragmented market landscape such as Europe as investors need to make sure that they are able to trade on fully incorporated prices (Harris, 2003). If the prices do not reflect all available information capital can be allocated inefficiently. Thereby somebody transmitting information between multiple markets can increase the welfare for all market participants. Against this context we wonder whether IT can reduce the mispricing across several venues. This could be shown if IT in financial markets can help to foster price homogeneity. In this study we widen our scientific lens towards HFT which heavily relies on IT (Chlistalla, 2011; Gomber and Haferkorn, 2013). HFT utilizes many strategies, one being the arbitrage trading strategy which creates a positive effect as it lessens the price dispersion. Other strategies used by HFT (e.g. multi-market market making as shown by Lescourret and Moinas (2015)) transmitting information between several markets are beneficial as well. Previous research suggests that overall HFT has a positive effect on securities trading. Due to their IT-advantage HFTs are able to adjust their orders very fast and thus trade within very short timespans resulting in better price efficiency (Brogaard, Hendershott, and Riordan, 2014). Thereby the nature of HFT being fast might increase market efficiency by quickly transmitting information cross-market. If we could observe this effect we would be witnessing a positive effect of HFT on the whole securities trading industry. Therefore we hypothesize:

$H1$: Increasing HFT-activity decreases the midpoint dispersion between distant markets.

If we observe that HFT-activity and midpoint dispersion are inversely connected, i.e. validate $H1$, we still can not be sure about the causality. Previous research has shown that market quality declined after regulatory events causing HFTs to adjust their behavior or quit the market (Friederich and Payne, 2015; Lepone and Sacco, 2013; Malinova, Park, and Riordan, 2013). We expect market efficiency to decline after regulating the behavior HFT thus we further hypothesize:

$H2$: Limiting HFT-activity increases the midpoint dispersion.

3.2 Dataset

3.2.1 Data Source

We use a dataset provided by Thomson Reuters Tick History (TRTH). The TRTH essentially provides two types of data: trade data and orderbook data, thereby the orderbook contains the limit and number of orders at the respective limit. Orderbook data is available for both sides of the book, i.e. bid and ask, starting from orderbook limit one to orderbook limit ten. Once the orderbook is updated (caused by an update or trade), a new dataset is saved by the TRTH millisecondwise, therefore we are able to observe HFT-activity almost instantaneously. The trade data contains the trades along with information of price and volume. We chose the equity market in France to analyze the effects as it is very technologically advanced and highly fragmented, as in previous studies we analyze a sample of a blue chip index. In our case we use constituents of the French blue chip index CAC 40 (Cotation Assistée en Continu quarante) as HFT is mostly active in these highly liquid securities. In this study we compare the two biggest competitors defined by market share (turnover), the Euronext Paris (main market) and the London based BATS Chi-X Europe (satellite market) which had a market share of 65.4% (Euronext Paris) and of 20.4% (Bats Chi-X Europe) (combined 85.8%) in CAC 40 lit trading in 2013 (Fidessa, 2014). Due to missing data in the TRTH we dismissed five constituents. Additionally three constituents are primary listed at Euronext Amsterdam which could potentially influence our results, thus we dismiss them as well. The timespan of our first sample is one year, i.e. 2013. The volatility was at normal levels in the year 2013 as no major events (like the Lehman bankruptcy in 2008) caused significant market turmoils. Analyzing one year omits monthly effects as for example observed by Odgen (1990). For our second step, the causality test, we further extend our sample with the German DAX 30 (Deutscher Aktienindex) constituents. Thereby we analyze the venues Deutsche Boerse and Bats Chi-X Europe, whereas the Deutsche Boerse (Bats Chi-X Europe) had in 2013 a market share of 69.4% (18.6%). Due to missing data we had to dismiss two securities. An overview over all securities analyzed along with their market capitalization is attached in the appendix (see page 18). We aggregate the data hour-wise in conformity with other studies (Huang and Masulis, 2003; Longstaff and Wang, 2004). Thereby we better reflect the short-term nature of HFT as a daily-wise aggregation could bias our results, especially when focusing on short-term dispersions between different markets.

3.2.2 Operationalization of Key Variables

Measuring HFT is quite challenging as public data feeds do not contain a flag whether an orderbook activity or trade is caused by an algorithm or a human. Researchers and regulators hence rely on a proxy to quantify HFT. One well established measure in academia and industry is the Order-to-Trade-Ratio (OTR) which utilizes a typical behavior of HFT: sending many orders while executing only a portion of them. Previous studies used the OTR (Haferkorn, Zimmermann, and Siering, 2013; Jørgensen, Skjeltorp, and Ødegaard, 2014; Lepone and Sacco, 2013; Malinova, Park, and Riordan, 2013) and its validity has been shown using a proprietary dataset (Haferkorn, Zimmermann, and Siering, 2013). Most importantly, the German legislature acknowledged the OTR as a measure for HFT and passed an act that forces exchanges to implement fees for traders having excessive OTRs (German High Frequency Trading Act, 2013). A similar regulation was passed by the Italian regulatory body as they enforced an OTR fee in 2012 aimed at limiting HFT-activity (Friederich and Payne, 2015). Our analysis incorporates a main and a satellite market (sat). We quantify the amount of HFT on both markets as the mean OTR. This aggregation is necessary as our other variables are also aggregated between both markets, i.e. midpoint dispersion. The OTR is calculated as follows:

$$OTR = \frac{Orders_{main} + Orders_{sat}}{Trades_{main} + Trades_{sat}} \tag{1}$$

Whereas $Trades_{main}$ ($Trades_{sat}$) is the number of trades and $Orders_{main}$ ($Orders_{sat}$) the number of orders at the main (satellite) market. As previously denoted the TRTH provides orderbook data at ten levels for each side of the orderbook sequentially. Thus, order submissions can only be obtained indirectly via TRTH as for example shown by He, Jarnecic, and Liu (2015); Lepone and Sacco (2013). We compute the total number of orders by comparing the amount of orders at each limit against the previous orderbook situation whereas an increase is a new submission. It is important to note that we can not observe market orders as they are executed immediately and no orderbook snapshot is being made in between submissions and execution. Previous research suggests that HFT (humans) typically use 4.63% (8.73%) of the time market orders (Jarnecic and Snape, 2014), therefore we assume that we capture most of the orders submitted by HFTs.

According to the efficient market hypothesis of Fama (1970) markets are efficient if all available information are reflected in the price. This also applies to securities markets where securities can be traded on distant trading venues. If the security price between distant venues start to diverge the efficiency of the whole market system declines. In efficient markets prices need to be identical independently from the location traded. Previous research suggests that one aspect of market efficiency is the price dispersion (Haiwei, Chen, and Valerio, 2003). In our study we take this definition a step further by analyzing the midpoint (MP) dispersion (MP_{disp}) for two leading venues. We thereby reflect the fact that a price resulting from a trade is not necessarily needed to transport information between distant markets as the MP itself inherits information about the current value of a security. Also in favor of the MP is the fact that using MP eliminates the bid-ask bounce (Gosnell, Keown, and Pinkerton, 1996; Schlag and Stoll, 2005). Taking these considerations into account we calculate the MP_{disp} between the two markets as follows:

$$MP_{disp} = \frac{abs(MP_{main} - MP_{sat})}{\frac{1}{2} * (MP_{main} + MP_{sat})} \tag{2}$$

$$MP_i = \frac{BestAsk_i + BestBid_i}{2} \tag{3}$$

Equation (3) exhibits the calculation of the midpoint for each venue, where i is main (sat) for the main (satellite) market. Since we are aiming at quantifying the total difference between both MPs we subtract them from each other (see equation (2)). As we are only interested in absolute MP dispersion between our both venues and not the direction (e.g. which venue has a higher MP) we further compute the absolute value. Taking into consideration that securities exhibit distinctive MP levels we additionally normalize the MP. Additionally, we include a set of controls as we expect that MP_{disp} is also influenced by other factors, in particular we include hourly and daily dummies as market activity varies over time (Chan et al., 1996; Jain, 1988; McInish and Wood, 1992). We expect that volatility influences the MP_{disp} as it influences activity of market participants, which has been in particular shown for HFTs by Benos and Sagade (2012). The volatility is calculated as mean standard deviation of the price volatility between both markets. Fore more robustness we include the industry concentration measure Herfindahl–Hirschman Index (HHI) to account for the fragmentation as proposed by Herfindahl (1950). It is calculated as follows:

$$HHI = \sum_{i=1}^{2} MS_i^2 \tag{4}$$

$$MS_i = \frac{To_i}{To_{main} + To_{chi}} \tag{5}$$

In the first step (equation (5)) the market share for each venue is calculated, where To_{main} (To_{chi}) is the turnover (measured in Euro) for the main (satellite) market. In the second step (equation (4) these two market shares are aggregated to one measure which is in our case 1 for a concentrated turnover on one market and 0.5 for a balanced turnover.

3.2.3 Descriptive Statistics of Key Variables

Table 1 shows the descriptive statistics of our long-term dataset. Considering the standard deviation of our OTR we observe a relatively medium level of fluctuations. As our data is aggregated hourly-wise and security-wise we observe the market on a macro level, i.e. the averaged HFT-activity over all market participants on both markets. We expect that the OTR of individual trading firms varies stronger due to the different technologies and strategies employed. By taking the magnitude of the OTR into account we observe that our OTR is similar to previous studies (Haferkorn, Zimmermann, and Siering, 2013;

Jørgensen, Skjeltorp, and Ødegaard, 2014). The average MP_{disp} is quite low and shows that price efficiency is quite high despite the fact that both venues are located apart. It is important to note is that MP_{disp} varies strongly compared to the median suggesting that even though both markets are balanced at most times the information transmission quality varies. This stresses the key problem of fragmented markets where HFT might help by simply transmitting information: fragmented pricing. We can observe that the fragmentation between our two markets, measured by the HHI, varies over time from nearly equally distributed (0.5) to concentrated (0.98). Taking into account that the mean is 0.59 we observe that at most times, trading between our two markets is fragmented.

Variable	**Median**	**Mean**	**Standard Deviation**	**Min**	**Max**
HHI	0.58	0.59	0.07	0.50	0.98
$MP_{disp} * 10^4$	0.20	9.10	28.11	0.00	363.78
$Orders * 10^{-2}$	202.70	249.08	174.40	12.01	25.71
OTR	19.02	21.78	12.02	3.60	279.56
Trades	1042.00	1310.10	990.42	56.00	19037.00
Volatility	0.05	0.07	0.23	0.00	1.17

Table 1: Descriptive statistics of our dataset for the long-term study containing CAC 40 securities.

The dataset for our short-term analysis is presented in table 2. As we conduct an event-study this dataset contains data from 20 days around the introduction of German HFT ACT on 15^{th} of May 2013. Regarding the descriptive statistics this dataset is similar to our previous one not exhibting a systematic difference.

Variable	**Median**	**Mean**	**Standard Deviation**	**Min**	**Max**
HHI	0.58	0.60	0.08	0.50	1.00
$MP_{disp} * 10^4$	0.26	0.97	19.23	0.00	279.38
$Orders * 10^{-2}$	184.99	228.19	165.98	17.12	2143.35
OTR	19.44	22.45	12.64	3.43	226.12
Trades	906.00	1178.02	1001.11	53.00	18363.00
Volatility	0.05	0.07	0.07	0.00	1.17

Table 2: Descriptive Statistics of our short-term dataset containing DAX 30 and CAC 40 securities.

4 Empirical Study

4.1 Relationship between Midpoint Dispersion and HFT

4.1.1 Regression Setup

In this section we investigate our hypothesis $H1$: increasing HFT-activity decreases the midpoint dispersion between distant markets. Due to the cross-sectional time series character of our data we make use of a standard methodology used in econometrics: the panel regression. Thereby we define each security as an entity (i) and every hour as a new timepoint (t). Our regression equation is as follows:

$$\begin{aligned} MP_{disp_{it}} = {} & \alpha_i + \alpha_1 OTR_{it} + \alpha_2 Orders_{it} + \alpha_3 Trades_{it} + \\ & \alpha_4 HHI_{it} + \alpha_5 Volatility_{it} + \sum_{j=6}^{n} \alpha_j C_{itj} + \varepsilon_{it} \end{aligned} \tag{6}$$

Where i is the entity number, t is the time, $\sum_{j=7}^{n} \alpha_j C_{itj}$ is a vector of dummy variables controlling for each trading hour and each day, ε_{it} is the idiosyncratic error term and α_i is the entity specific intercept. We further include stepwise the number of orders ($Orders_{it}$) and trades ($Trades_{it}$) in our regression as we want to evaluate whether OTR gives us a superior explanation of MP_{disp}, thus eliminating the individual effect of both originating variables. For additional robustness we estimate our regressions without both of these variables. We run our regression at first on the basis of a fixed effects model. By using the fixed effects (FE) model we allow for constant effects among the entities influencing the independent variables caused by the unobservable heterogeneity (Wooldridge, 2009). Estimating time series is non-trivial as underlying trends might cause heteroscedasticity, therefore we use heteroscedasticity-consistent standard errors (also referred as Huber-White Sandwich Estimator) as proposed by White (1980). Further a regression on time series might inhibit serial correlation in the idiosyncratic errors. Thus, we run a Wooldridge Test for serial correlation which reveals that some autocorrelation within our error term exists (Wooldridge, 2002). Consequently, the regression is estimated with a GLS estimator modeling the disturbance as autoregressive process AR(1) as proposed by Baltagi and Wu (1999). The significance levels stay comparable to the previous approach therefore we dismiss autocorrelation as a major issue in our estimation. As our panel exhibits a small number of entities (small i) and a long time series (large t) we further add robustness by estimating our regression on the basis of the Fama-MacBeth method (Fama and MacBeth, 1973; Skoulakis, 2008). The significance levels are similar and due to space limitations these results are omitted. For the following regressions we use the long-term dataset. Descriptive statistics are shown in table 1.

4.1.2 Regression Results

The estimation results with standardized coefficients are shown in table 3, where models (1) - (4) are fixed effects models (FE) and (5) - (8) are AR(1) models. In the first step, i.e. model (1) and (5), we conduct a univariate regression of MP_{disp} on OTR, the key variables in question. The results of these regressions suggest that OTR and MP_{disp} are significantly negatively related. In the next two models (2) and (6) we additionally include Orders and Trades, even with these two variables our OTR stays significant thus the effect being observed cannot solely be attributed to these variables. In the next step (models (3) and (7)) we include our controls which greatly improves the explanatory power. Still the coefficient of our OTR remained significantly negative. Since multicollinearity between the OTR and Orders/Trades might be an issue in our estimation we estimate the full regression without these variables (models (4) and (8)). Again the significance of our OTR stays the same. Interestingly we observe that the HHI, the industry concentration measure, turns significant with a negative coefficient in our AR(1) estimation. This means that a more monopolistic market decreases MP_{disp} and validates our initial assumption that trading is not necessary to transmit information between our two markets. Additionally this could be an indication that one of both markets processes most of the information as shown by Jung and Katzschner (2012); Ryan, Storkenmaier, and Wagener (2011). We can confirm our initial research hypothesis $H1$ as our results indicate a significant negative effect of the OTR on the MP_{disp}, which is beneficial as a rise in of OTR decrease MP_{disp}. Thus, HFT-activity lessens the midpoint dispersion between our two markets. Still we need to assess the causality between HFT and MP_{disp}.

	(1) **FE**	(2) **FE**	(3) **FE**	(4) **FE**	(5) **AR(1)**	(6) **AR(1)**	(7) **AR(1)**	(8) **AR(1)**
OTR	-0.269***	-0.223***	-0.041**	-0.029***	-0.286***	-0.231***	-0.042***	-0.028***
	(-8.89)	(-6.32)	(-3.12)	(-4.36)	(-69.59)	(-40.10)	(-13.64)	(-12.95)
Orders		-0.203***	0.004			-0.217***	0.013**	
		(-3.70)	(0.19)			(-27.20)	(2.93)	
Trades		-0.029	-0.036*			-0.038***	-0.038***	
		(-0.88)	(-2.63)			(-5.15)	(-9.49)	
Hour Controls			Included	Included			Included	Included
Daily Controls			Included	Included			Included	Included
HHI			-0.006	-0.008			-0.005*	-0.008***
			(-1.26)	(-1.87)			(-2.55)	(-3.80)
Volatility			-0.003	-0.005			-0.003	-0.004 *
			(-0.95)	(-1.08)			(-1.71)	(-2.31)
Observations	72128	72128	72128	72128	72096	72096	72096	72096
Adjusted R^2	0.063	0.090	0.746	0.746	0.063	0.093	0.747	0.746

Table 3: This table represents our regression results on MP_{disp}, we stepwise increase the number of variables to show the robustness of our regression and further to observe the superior explanatory power of the OTR against the variables Orders and Trades. The models (1) - (4) are obtain via a fixed effects regression with heteroscedasticity-consistent standard errors (also referred as Huber-White Sandwich Estimator) as proposed by White (1980). To add further robustness and to reflect the timer-series character of our dataset, we further estimate the regression with a GLS estimator modeling the disturbance as autoregressive process AR(1) (models (5) - (8)) (Baltagi and Wu, 1999). The reported coefficients are standardized, the t statistics are in parentheses and significance levels are as follows: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

4.2 Causality Test - The German High-Frequency Trading Act

4.2.1 Regression Setup

For our causality test we exploit a recent regulatory event limiting HFT-activity in a highly technological advanced market: the German HFT Act. The act aims at regulating HFTs by introducing organizational and authorization requirements to HFTs. Despite these requirements trading of HFT is directly affected as exchanges were forced to introduce excessive usage fees based on the OTR, essentially putting a levy on trading firms exhibiting a high OTR (German High Frequency Trading Act, 2013). The beauty of the German HFT act is that it only applies to HFTs within Germany, i.e. venues outside of Germany were not affected. This event is similar to the introduction of an excessive message fee in Canada and Italy which caused HFTs to reduce their activity (Friederich and Payne, 2015; Lepone and Sacco, 2013; Malinova, Park, and Riordan, 2013). Event studies are well established in IS-research and commonly used in financial market research (Riordan and Storkenmaier, 2012; Roztocki and Weistroffer, 2009). Previous research on the German HFT Act has shown that HFT adjusted its behavior after the introduction of the act by reducing the amount of messages being sent (Haferkorn and Zimmermann, 2015). In line with previous research on the act we make use of well-known methodology proposed by Snow (1855): the difference-in-differences method. The difference-in-differences method is used in various fields to analyze the effects of treatment against the untreated group (control group). Thereby the analysis relies on a group which receives the treatment and a control group which is not exposed to treatment. While during the pre-treatment period the systematic bias between both groups is removed, the systematic difference in the post-treatment group is the treatment effect (Wooldridge, 2002). Within our setting we want to study the effect of the German HFT Act on the MP_{disp} of our two markets, therefore we derive our treatment group from the constituents of the DAX 30. We choose the largest venue in Germany by turnover, the Deutsche Boerse where no changes in the market or fee structure were made during our event horizon. The ideal control group is a group which exhibits a high level of similarity. We chose the CAC 40 for the following reasons: The CAC 40 displays a high price level correlation with the DAX 30 (0.87 six months before the event) and further a significant portion of the CAC 40 / DAX 30 constituents are part of the EURO STOXX 50 index. Secondly, both countries are located geographically nearby and use the same currency, thus both countries exhibit a macro-economic similarity. Thirdly, both indices were used previously as complementing control groups (Gunther and Olena, 2014). Similarly to our previous procedure we calculate MP_{disp} between the main market (Deutsche Boerse for DAX 30 and Euronext Paris for CAC 40 securities) and the satellite market (Bats Chi-X Europe). Benchmarking against the same satellite market adds further robustness to our approach as the control sample gets more similar to the treatment sample. We modify our regression equation (6) from the previous section by adding an indicator variable for pre and post-treatment interval ($Time_t$) and an interaction term ($German_i * Time_{it}$). As we expect that the event has an effect on the OTR we dismiss this variable along with Orders and Trades. The regression equation is as follows:

$$\begin{aligned} MP_{disp_{it}} = {} & \alpha_i + \alpha_1 German_i * Time_{it} + \alpha_2 Time_t + \alpha_3 German_i + \\ & \alpha_4 HHI_{it} + \alpha_5 Volatility_{it} + \sum_{j=6}^{n} \alpha_j C_{itj} + \varepsilon_{it} \end{aligned} \tag{7}$$

Thereby $Time_t$ changes from zero to one when the German HFT Act becomes active (i.e. on the 15^{th} of May 2013) and $German_i$ is zero for observations from the control group (CAC 40) and one for observations in the treatment group (DAX 30). Thus, the interaction term ($German_i * Time_{it}$) is only one for the DAX 30 observations after the introduction of the German HFT Act, which shows the treatment effect of the HFT Act. We chose a ± 10 trading day observation window around the event date (i.e. from 15^{th} of April 2013 until the 27^{th} of May 2013) like in previous event studies (Kolari and Pynnönen, 2010; Lease and Page, 1991). For this analysis we use the short-term dataset, descriptive statistics for this dataset can be found in table 2. Similar to the procedure in the previous section we run the regression followed by a test against serial correlation which we can confirm. In line with our previous approach, we model the disturbance as autoregressive process AR(1), thereby we observe similar significance levels to the previous approach. Thus we dismiss autocorrelation as a major issue in our estimation.

4.2.2 Regression Results

The results of our regressions are depicted in table 4. Considering our two models (9) and (10) we can observe that the time effect (variable $Time$) is significant positive. Thus, the overall MP_{disp} deteriorates between our pre and post-event period at both market systems, which might be an effect caused by seasonal changes. Taking into account the positive coefficient of our interaction term ($German * Time$) we can observe that the German HFT Act caused a significant systematic increase in the MP_{disp} between DAX 30 securities listed at Deutsche Boerse and Bats Chi-X Europe. Thus, we can accept $H2$ (limiting HFT-activity results in an increase of MP_{disp}). These results suggests that the HFTs who balanced the MP between the two markets adjusted their behavior or quit their operation. This side-effect should be seen critically as it increases the chance that investors do not trade on fully incorporated prices at the both venues, i.e. Deutsche Boerse and Bats Chi-X Europe. Thereby the partial absence of HFT affects one market efficiency criterion negatively: MP homogeneity. These observations are in line with the results of Friederich and Payne (2015); Lepone and Sacco (2013); Malinova, Park, and Riordan (2013) who observed that regulation limiting at HFT-activity worsens market quality. Regarding our initial hypothesis we can confirm that HFT plays an important role in a fragmented market system (such as Europe) by transmitting information between several markets.

	(9) **FE**	**(10)** **AR(1)**
$German * Time$	0.025***	0.031*
(German HFT ACT effect)	(3.57)	(2.17)
German	0	
	.	
Time	0.026***	0.067***
	(3.96)	(2.39)
Daily Controls	included	included
HHI	included	included
Hour Controls	included	included
Volatility	included	included
Observations	9222	9162
Adjusted R^2	0.458	0.455

Table 4: This table shows the results of the diff-in-diff regression exhibited in equation (7), Time is a variable which switches from zero to one at the 15th of May 2013 and is one for German and zero for French observations. The German*Time Variable shows the effect of the German HFT Act on the MP_{disp}. The reported coefficients are standardized, respective t-values are in brackets and significance levels are as follows: *p<0.05; **p<0.01; ***p<0.001.

5 Discussion

5.1 Theoretical and Practical Contributions

With this study we give input to a prevalent question in IS-research: What is the economic value of IT? First, our research contributes to the 4^{th} research thrust of Kohli and Grover (2008) showing intangible paths to economic value IT. We unveil the economic value of IT in financial markets by giving evidence that HFT can help to lessen the MP dispersion in a fragmented market system such as Europe. With this study we add to the research stream on the industry-wide effects of IT in financial markets. In particular we add to IS-research on automated traders which predominately focused on a single market setting and market quality (Haferkorn, Zimmermann, and Siering, 2013; Zhang and Riordan, 2011). This study widens the academic lens to a fragmented market setting and market efficiency.

Our study further contributes to two important topics in market microstructure research: HFT and fragmentation. Previous studies suggested that HFT has positive effects on the market quality and efficiency (Brogaard, Hendershott, and Riordan, 2014; Hasbrouck and Saar, 2013; Malinova, Park, and Riordan, 2013), however contrary effects have also been reported (Kirilenko et al., 2014; Zhang, 2010). We add to the discussion by introducing a new aspect to HFT research: fragmented markets. Within our approach we empirically show that HFT measured by the OTR decreases the MP dispersions among two leading European venues in a fragmented market. By analyzing the effect of the German HFT Act we further show that HFTs, who balanced the prices among the two largest venues for German equities, changed their behavior or simply quit the market since the introduction of the act. This resulted in a decline of market efficiency. Regulators need to carefully assess each regulatory intervention as the securities trading industry has been becoming more and more complex over the last years. This paper gives evidence for the regulatory body, especially in light of the upcoming MiFID II (European Commission, 2014). The evidence is particularly needed as MiFID II proposes several rules aimed at HFT and exchanges. Taking into consideration the most recent HFT-regulation, the German HFT Act, our event study suggests that a negative effect in the form of a higher MP dispersion arose which now affects all market participants. These results are in line with observations being made in Canada and Italy (Friederich and Payne, 2015; Malinova, Park, and Riordan, 2013) where it was shown that limiting HFT-activity decreased market quality.

5.2 Limitations and Future Research

Our research approach has some limitations. In this study, we analyzed whether HFT can cause a positive effect on the whole securities trading industry by decreasing MP dispersion. While we find that HFT can create a positive spillover by reducing the MP dispersion it is important to note that we analyzed only one aspect of HFT. As HFT employs various strategies, general conclusions towards HFT can not be drawn from our results easily. However, this does not interfere with our core result which is that IT in the securities trading industry can cause positive spillover on firms and individuals who are not investing in the IT directly. Also important to note is that our proxy, the OTR, might not capture all HFT induced activity. For example HFTs using market orders rather than limit orders or submitting the same amount of orders as executed are not captured precisely. Previous research suggests that HFT uses limit orders 95.37% of the time and cancels them 47.01% of the time (Jarnecic and Snape, 2014), therefore we do not regard this as a major issue in our research approach. Further our analysis is carried out within the European market landscape which has an unique market structure. Therefore the observations being made might not be easily transferable thus hindering the generalizability of our results.

There are many interesting research directions which could be pursued in the future. For example our research could be expanded towards a triple or more market case to gain a deeper understanding of HFT in the interconnected securities landscape. Taking into account the limitation that we only analyzed the

European securities market a focus on the U.S. market would be fruitful in adding generalizability to our results, especially since the U.S. market displays a high level of HFT-trading.

6 Conclusion

With this paper we follow the call of Kohli and Grover (2008) to demonstrate indirect paths to the economic value of IT, hereby we put our attention on the industry level as it was neglected by academia. Researching the effect of IT used in an industry is quite challenging, as it is hard to measure the IT-utilization in a timely and precise manner. Hereby we chose an industry which is characterized by a high IT-intensity: the highly technologized securities trading industry. The securities trading industry undergoes a tremendous development as new technologies such as Smart Order Routing and High-Frequency Trading gains more and more importance. Especially HFT attracts attention as it accounts for 24% - 43% of the value traded in Europe (European Securities and Markets Authority, 2014). But how do these automated traders affect the market quality and efficiency, especially in a fragmented market landscape?

HFT relies heavily on IT as it needs to be able to evaluate new information within milliseconds (Brogaard, Hendershott, and Riordan, 2014; Chlistalla, 2011). We wonder if this characteristic can be beneficial, thus creating a positive effect for the securities trading industry. Previous research has analyzed new technologies and regulatory events by studying effects on market quality and efficiency (Gomber et al., 2013; Riordan and Storkenmaier, 2012). In light of the efficient market hypothesis of Fama (1970), prices need to be homogenous incorporating all information instantly. As today's securities markets are highly fragmented fragmented pricing can occur. We wonder if HFT can decrease the price dispersion among European trading venues, i.e. fostering price homogeneity. We investigate this question by comparing the differences between Euronext Paris and Bats Chi-X Europe in 2013. We find that HFT-activity measured by the OTR lessens the dispersion, thus we can confirm in this case that HFT creates a positive spillover for the securities trading industry. To further assess the causality between HFT and price dispersion we conducted an event study on a recent regulatory event that only affected HFTs in Germany, the German High-Frequency Trading act. As the act increased regulatory requirements on HFT and forces exchanges to introduce message-fees we previous research suggests that HFTs changed the behavior or even quit the market, i.e. the HFT-activity (IT-usage) was reduced at the German market. For German equities trading we find that the reduction of HFT-activity increased price dispersion among the two leading venues, i.e. Deutsche Boerse and Bats Chi-X Europe. Further this event unveils the effect of IT in the form of HFT on market efficiency, which we find to be beneficial in this context.

With this study we contribute to the realm of IS and market microstructure research. In area of IS-research we provide evidence on the basis of the securities trading industry that IT-usage can be beneficial for a whole sector. Additionally we contribute to the research stream on IT in financial markets, which focused mostly on exchange systems. Concerning market microstructure research, we give another insight on the prevailing dispute on HFT. We widen the academic lens to fragmented markets and observe that HFT can increase market efficiency by balancing prices among our analyzed markets. Additionally we give input to the discussion about the regulation of HFT. Thereby we analyzed the effect of the German HFT Act. This led us to the conclusion that market efficiency declined, thus, highlight that the regulatory body needs to carefully assess each intervention in such a complex system as the financial market.

Even though we utilized various regression techniques and we are confident that our estimations are robust our research still has some limitations. As we only focused on the European market the generalizability of our results might be restricted. However this does not interfere with our core result that IT in financial markets can create a positive spillover for firms not investing in IT firsthand. We analyzed HFT on the basis of the OTR which does not capture all HFT-activity within a financial market, therefore the usage of a better proxy or a proprietary dataset would be helpful. We want to point out that further research is necessary before drawing general conclusions regarding HFT and regulation. Future research should focus on different markets and market systems to foster a better understanding of HFT.

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Appendix

Analyzed Securities

Name	Market Capitalization	Name	Market Capitalization
AXA	43.50	Adidas	18.70
Accor	8.03	Allianz	62.92
Air Liquide	35.88	BASF	88.64
Alcatel-Lucent	3.26	Bayer	77.92
Alstom	12.15	Bayerische	68.76
BNP Paribas	70.93	Beiersdorf	15.59
Bouygues	32.42	Commerzbank	11.48
Cap Gemini	6.35	Continental	23.51
Carrefour	18.68	Daimler	59.90
Compagnie de Saint Gobain	23.16	Deutsche Bank	42.22
Credit Agricole	20.43	Deutsche Börse	11.45
Danone	40.33	Deutsche Lufthansa	8.94
EDF	34.20	Deutsche Post	27.42
Essilor International	21.95	Deutsche Telekom	49.65
GDF Suez	50.14	E.On	36.09
L'Oreal	86.18	Fresenius Medical Care	20.78
Lafarge	18.66	Fresenius	30.77
Michelin	17.68	Heidelberg	11.67
Louis Vuitton Moet Hennessy	95.15	Infineon	9.12
France Telecom	29.67	K&S	8.88
Pernod Ricard	30.72	Lanxess	7.36
Publicis Groupe	10.95	Linde	32.28
Renault	16.40	Merck	21.70
SUEZ ENV	6.18	Muenchener	32.89
Schneider Electric	41.52	RWE	24.01
Societe Generale	27.12	SAP	98.50
Technip	13.38	Siemens	93.47
Total	124.38	ThyssenKrupp	12.68
Vallourec	6.64		
Veolia Environ	14.95		
Vinci	28.06		
Vivendi	30.40		

Table 5: Stocks used in our analysis and their respective market capitalization on the 2nd of January 2013 (in billion Euro).