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What is the value of retail order flow?

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Non-technical summary

Research question

Retail trading in equity markets has grown strongly over recent years on the back of commission-free trading, low interest rates, and the COVID-19 pandemic. While some commentators point to the benefits of increased stock market participation, others have raised concerns about the gamification of trading and conflicts of interest in the brokerage industry. The long-standing practice of payment for order flow (PFOF) is at the heart of an intense debate that has led to regulatory action. While the Securities and Exchange Commission (SEC) is currently reviewing equity market structure in the United States, the European Union has gone further and announced a ban on PFOF.

Contribution

This paper aims to contribute to the ongoing debate by improving our understanding of the economic forces underlying PFOF, or retail order flow segmentation more broadly. We use regulatory data from Germany to assess the value of retail order flow from the perspective of financial intermediaries. More specifically, we examine the performance of five specialized retail market makers (RMMs) which handle a significant share of retail investor trading in the German equity market via affiliated trading venues.

Results

These RMMs trade frequently in a wide range of securities, maintain low inventories, and generate significant risk-adjusted returns. For comparison, we also dissect the activity of other 21 proprietary trading firms (PTFs) in the German equity market. These firms exhibit similar overall behavior (high trading volume, low inventories), but trade almost exclusively in public limit order markets and do not purchase retail order flow. Importantly, they generate significantly lower risk-adjusted returns. Finally, we examine why retail market making is so profitable. First, we show that the order flow absorbed by RMMs is free of adverse selection risk, consistent with retail investors not possessing any private information. Second, we contrast the behavior of RMMs' and PTFs' intraday inventories, and find that RMMs' inventories exhibit a significantly faster mean-reversion. This suggests that they are also less exposed to undue price movements as a result of intermediation activity. We further show that at least part of this effect arises because retail order flow they face is more balanced than the order flow in the overall market. In sum, retail market making is a relatively low-risk activity. From the regulators' perspective, the significant profitability of retail market making gives rise to concerns about possible negative effects on market liquidity. The main market is deprived of order flow that acts as valuable "lubricant" for market liquidity. However, since RMMs offload unbalanced inventory positions quickly,

a significant share of retail trading ultimately ends up in public markets, which could possibly attenuate some of the adverse effects of order flow segmentation.

Nichttechnische Zusammenfassung

Fragestellung

Der Handel von Privatanlegern an den Aktienmärkten hat in den letzten Jahren aufgrund des provisionsfreien Handels, niedriger Zinsen und der COVID-19-Pandemie kräftig zugenommen. Während einige Kommentatoren auf die Vorteile einer verstärkten Aktienmarkteteiligung hinweisen, haben andere Bedenken hinsichtlich der „Gamifizierung“ des Handels und möglicher Interessenkonflikte in der Maklerbranche geäußert. Die etablierte Praxis der Rückvergütung (Payment for Order Flow, PFOF) steht im Zentrum einer intensiven Debatte, die sich in regulatorischen Maßnahmen niederschlägt. Während die Securities and Exchange Commission (SEC) derzeit die Aktienmarktstruktur in den Vereinigten Staaten überprüft, hat die Europäische Union ein PFOF-Verbot angekündigt.

Beitrag

Dieses Papier trägt zur laufenden Debatte bei, indem es unser Verständnis der wirtschaftlichen Kräfte, die dem PFOF zugrunde liegen, oder der Segmentierung der Aufträge von Privatanlegern im weiteren Sinne verbessert. Wir verwenden regulatorische Daten aus Deutschland, um den Wert des Orderflusses von privaten Haushalten aus Sicht der Finanzintermediäre zu bewerten. Im Einzelnen untersuchen wir die Performance von fünf spezialisierten Retail Market Makern (RMMs), die einen erheblichen Anteil der Aufträge von Privatanlegern am deutschen Aktienmarkt über verbundene Handelsplätze abwickeln.

Ergebnisse

Diese RMMs handeln häufig mit einem breiten Spektrum an Wertpapieren, halten niedrige Bestände und erzielen erhebliche risikobereinigte Renditen. Zum Vergleich wird auch die Aktivität anderer 21 Eigenhandelsunternehmen (Proprietary Trading Firms, PTFs) am deutschen Aktienmarkt analysiert. Diese Unternehmen weisen ein ähnliches Gesamtverhalten auf (hohes Handelsvolumen, geringe Bestände), handeln aber fast ausschließlich an öffentlichen Limit-Order-Märkten und betreiben kein PFOF. Wichtig ist, dass sie deutlich geringere risikobereinigte Renditen erzielen. Schließlich untersuchen wir, warum das Market-Making für Aufträge von Privatanlegern so profitabel ist. Erstens zeigen wir, dass der von RMMs absorbierte Auftragsfluss frei von adversen Selektionsrisiken ist, was mit der Interpretation einhergeht, dass Kleinanleger keine privaten Informationen besitzen. Zweitens stellen wir das Verhalten der Innertagesbestände von RMMs und PTFs gegenüber und stellen fest, dass die Bestände von RMMs eine deutlich schnellere Mittelrückkehr aufweisen. Dies deutet darauf hin, dass sie auch weniger dem Risiko zwischenzeitlicher Preisbewegungen infolge der

Intermediationstätigkeit ausgesetzt sind. Außerdem zeigen wir, dass zumindest ein Teil dieses Effekts darauf zurückzuführen ist, dass die Aufträge von Privatanlegern ausgeglichener sind als der Auftragsfluss am Gesamtmarkt. Insgesamt ist das Market-Making für Aufträge von Privatanlegern ein relativ risikoarmes Geschäft. Aus regulatorischer Sicht gibt die beträchtliche Profitabilität des Retail Market Making Anlass zu Bedenken hinsichtlich möglicher negativer Auswirkungen auf die Gesamtmarktliquidität. Dem Hauptmarkt wird der Orderfluss entzogen, der als wertvolles „Schmiermittel“ für die Marktliquidität fungiert. Da RMMs jedoch unausgeglichene Bestände rasch weiterreichen, gelangt letztlich ein erheblicher Teil der Privatanlegeraufträge an öffentliche Märkte, was möglicherweise einige negative Auswirkungen der Auftragssegmentierung abmildern könnte.

What is the value of retail order flow?*

Peter Hoffmann[†] Stephan Jank[‡]

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Abstract

This paper uses regulatory data to assess the value of retail order flow in the German equity market. To this end, we examine the performance of specialized retail market makers (RMMs) that internalize a large share of retail activity via affiliated trading venues. We show that retail market making is extremely profitable, with an average (gross) Sharpe ratio of 17.85, which is more than twice as large as that earned by proprietary trading firms (PTFs) active in public limit order markets. A simple calculation suggest that RMMs would be willing to give up around 60% of their revenues, or 1.76 bps of their trading volume, for access to retail order flow. The profitability of retail market making is rooted in reduced exposure to adverse selection and inventory risk.

Keywords: Equity markets, retail trading, market making, internalization, payment for order flow.

JEL Codes: G10, G12.

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1 Introduction

Retail trading in equity markets has grown strongly over recent years, fuelled by the rise of commission-free trading and the combination of low interest rates, large-scale fiscal stimulus and the COVID-19 pandemic. While there is evidence that retail investors on aggregate have performed well (Welch, 2022) and helped to improve market liquidity (Ozik et al., 2021), economists and regulators have become increasingly concerned about the “gamification” of trading (Barber et al., 2022) and conflicts of interest in the brokerage industry (Egan, 2019).

Much of the debate has centered around the market structure for retail trading, including the practice of “internalization” and “payment for order flow” (PFOF). While not a new phenomenon, the events surrounding the meme-stock frenzy of January 2021 and the decision of brokerage firm Robinhood to halt trading in affected securities catapulted lead to a wave of public outrage.¹ In the aftermath, the US Securities and Exchange Commission called for an overhaul of US retail equity market structure and an investigation into the implications of PFOF. In Europe, lawmakers went further and recently decided to ban PFOF altogether from 2026 onwards.²

In this paper, we contribute to the debate on retail equity market structure by providing a comprehensive assessment of the value of retail order flow. The key premise of PFOF is that the intermediation of retail order flow is profitable, which enables brokers to charge a fee for directing their customers’ orders towards specialized intermediaries. If brokers can exert at least some market power, the size of the kickback they can extract

¹See “This is the way: the Reddit traders who took on Wall Street’s elite”, Financial Times, 29 January 2021.

²See “SEC aims to stem trading practice of payment for order flow”, Financial Times, 8 June 2022, and “EU agrees deal on securities rules that includes ban on broker commission”, Reuters Newswire, 29 June 2023. Notably, PFOF is already illegal in several EU countries, but common practice in others.

should depend on the profitability of retail market making.

To this end, we use detailed regulatory data on the trading activity of five specialized retail market makers (RMMs) in the German equity market. They jointly account for more than half of all retail order flow, which is largely internalized via a set of RMM-affiliated trading venues. We assess their trading activity and profitability (on a gross basis) and contrast it with a large group of proprietary trading firms (PTFs) active in the German equity market. Our findings are as follows.

First, we show that RMMs exhibit a trading behaviour that is broadly similar to that of PTFs as documented in the literature (e.g., [Kirilenko et al., 2017](#)). They handle significant trading volume (122 million EUR per RMM-day) and maintain very low inventory positions (less than 1% of total volume). While the bulk of their trading occurs in affiliated trading venues against retail investors, a significant share of this order flow ultimately ends up in public limit order markets (PLOMs) because RMMs aim to maintain tight inventories.³ We also show that only about 85% of RMM volume is executed during regular trading hours (RTH), with the remaining share traded before the open or after the close.

We then evaluate RMMs' trading profits. Overall, retail market making is vastly profitable, especially on a risk-adjusted basis. The average RMM earns a daily return of 20.11 bps and exhibits a Sharpe ratio of 17.85. Interestingly, we find that almost half of their profits are generated outside regular trading hours (OTH), even though it only

³We use the term “public limit order market” (PLOM) as an umbrella term for all multilateral trading venues with i) transparent limit order books that ii) cater to a broad base of market participants and iii) are not dominated by a single liquidity provider. These markets are responsible for price discovery. In our context, this includes Xetra, the electronic limit order book of the German stock exchange, as well as a number of multilateral trading facilities (MTFs) that act as direct competitors (e.g. CBOE, Turquoise, Acquis), but do not have official exchange status. It is important to distinguish these venues from RMM-affiliated venues, some of which are technically also classified as exchanges or MTFs (other operate as “systematic internalisers”). Their business model is entirely focused on retail investors, and thus fundamentally different.

accounts for only around 15% of trading volume. However, the increased profitability of OTH trading also comes with higher risk, so it only offers a marginally higher Sharpe ratio.

Next, we contrast RMMs' activity with that of 21 PTFs active in the German equity market. While these PTFs trade similar volumes, their activity is concentrated in the 100 most liquid stocks. They also keep somewhat larger overnight inventory positions (around 10%), and trade almost exclusively in PLOMs. While PTFs earn higher revenues per EUR traded than RMMs (3.82 vs. 2.55 cents per 100 EUR), these come at the expense of higher capital use and higher risk-taking. We find an average Sharpe ratio of 7.42 across our 21 PTFs, and an average daily return of 6.03 bps. While PTFs earn sizeable profits on a risk-adjusted basis, RMMs are significantly more profitable.

We then provide a simple back-of-the-envelope calculation that aims to quantify the value of retail order flow. We do so by assuming that a trading firm can either i) act as PTF in PLOMs, or ii) become an RMM. Since RMMs earn higher risk-adjusted returns than PTFs, the value of retail order flow is then equal to the trading firm's willingness to pay for becoming an RMM. Given our profitability estimates, a simple calculation shows that RMMs would be willing to give up 27.1 million EUR per year (1.76 bps of total trading volume), or close to 60% of their trading revenues. Scaled to the size of the U.S. stock market, this corresponds to 1.56 billion USD/year. Overall, these numbers compare rather well to those reported in recent literature ([Ernst and Spatt, 2022](#); [Schwarz et al., 2022](#); [Bryzgalova et al., 2022](#)) and the financial press.

Finally, we explore the sources of the differential profitability of retail and wholesale order flow. First, we examine the role of adverse selection by decomposing the effective spread into a short-term price impact and the realized spread. Our results suggest that

the retail order flow absorbed by RMMs does not generate any price impact, and is thus completely uninformed. This enables RMMs to provide some price improvement, but at the same time earn significantly higher realized spreads.

Second, we look at differences in inventory risk. We show that RMMs' inventories exhibit a significantly faster mean reversion than those of PTFs (with half-lives of 15.9 and 41.8 minutes, respectively). We then decompose the mean reversion speed into a passive and an active component, and find that this result is driven by i) retail order flow being more balanced, and ii) RMMs being more aggressive in offloading any non-zero inventory positions.

Our findings can inform the regulatory debate on retail equity market structure. The internalization of retail flow is highly profitable because it exposes intermediaries to significantly lower risk compared to the order flow in PLOMs. These results are consistent with the cream-skimming view of internalization ([Easley et al., 1996](#)) and give rise to concerns about the possible negative effects on overall market liquidity. However, as RMMs offload unbalanced inventory positions quickly, a significant share of retail trading ultimately ends up in PLOMs, which may attenuate some of the adverse effects of order flow segmentation.

Related Literature. Our paper contributes to the fast-growing literature on the microstructure of retail equity markets. While its origins date back to the rise of internalization in the 1990s (e.g. [Röell, 1990](#); [Easley et al., 1996](#); [Battalio et al., 1997](#)), this literature has attracted renewed attention in recent years as a result of the retail investor boom triggered by the COVID-19 pandemic and public controversies surrounding the rise of commission-free brokerage accounts, trading halts in “meme stocks” and the

controversy surrounding PFOF.

In this context, several recent papers study the execution quality of small retail orders under PFOF arrangements relative to the benchmark of exchange-based trading ([Adams et al., 2021](#); [Schwarz et al., 2022](#); [Levy, 2022](#); [Dyhrberg et al., 2022](#)). Overall, the evidence is consistent with i) retail investors receiving price improvement and ii) significant variation in investors' trading costs. However, there is no consistent relationship between wholesalers' execution quality and PFOF. Some of this literature focuses on retail trading in equity options, which has exploded recently and now accounts for about half of the total market ([Bryzgalova et al., 2022](#)). [Ernst and Spatt \(2022\)](#) show that PFOF in options is large and argue that this incentivizes brokers to tilt their clients towards options trading. [Hendershott et al. \(2022\)](#) study auctions in options markets through which wholesalers internalize retail order flow. While they find evidence for price improvements, they also argue that wholesalers engage in cream-skimming.

The growth of PFOF has also led to new theoretical work that examines why such arrangements can be profitable for market makers. [Parlour and Rajan \(2003\)](#) develop a model where PFOF creates rents for liquidity providers by softening competition. [Barardehi et al. \(2021\)](#) show that wholesalers decide which retail flow to internalize and which to send on to the exchanges in response to liquidity demand by institutional investors. Accordingly, they use retail flow as a source for inventory management. [Baldauf et al. \(2023\)](#) develop a model consistent with this view, where the internalization of retail order flow helps to reduce inventory risk at the portfolio level. Finally, [van Kervel and Yueshen \(2023\)](#) develop a model where the possibility to execute order flow off-exchange induces intermediaries to scale back on-exchange liquidity provision. In line with a recent SEC proposal, [Ernst et al. \(2022\)](#) develop a theoretical model to shed light on the merits

of a move from PFOF to competitive order-by-order auctions. They argue that, under some conditions, auctions may give rise to a winner’s curse that could harm retail investor welfare.

A third strand of the literature analyzes the performance of retail investors and their impact on overall market quality. Some authors provide evidence that retail investors do well on average and their trading predicts future returns and helps to stabilize markets (Boehmer et al., 2021; Ozik et al., 2021; Welch, 2022). However, other point towards “attention-induced trading” by first-time investors (Barber et al., 2022), increased inventory risk from herding behaviour (Eaton et al., 2022) and negative volatility spillovers from retail options trading (Lipson et al., 2023). These developments were likely fuelled by the widespread removal of trading commissions (Even-Tov et al., 2022).

Finally, our paper is also related to several papers that examine the returns to intermediation activity and their determinants. Most notably, Menkveld (2013) and Baron et al. (2019) analyze the profitability of PTFs in Dutch and Swedish equities and point to the role of speed for managing adverse selection risk and inventory control. Anand and Venkataraman (2016) show that the profitability of market making on the Canadian equity market exhibits significant commonality, and counterintuitively increases with volatility. Van Kervel and Menkveld (2019) and Korajczyk and Murphy (2019) examine the effects of PTFs on the execution costs of other market participants. Overall, PTFs appear to impose some costs on large institutional investors, but benefit smaller investors.

2 The retail trading landscape in Germany

The laboratory for our analysis is the German equity market. Despite an overall rather low level of stock market participation compared to other advanced economies (see, e.g. [Giannetti and Koskinen, 2010](#)), the structure of the German market for retail trading in equities closely resembles that of many other countries, including the United States.

Retail customers in Germany typically access the stock market via a brokerage account held at a bank or a standalone broker. Following the success of Robinhood in the United States, a number of so-called “neo-brokers” entered the market starting in 2019 in order to capitalize from a retail trading boom spurred by low interest rates and amplified by the COVID-19 pandemic. Their business model is largely built on ultra-low commissions financed through PFOF and easy-to-use trading apps aimed at a younger generation of investors. Examples for neo-brokers include Trade Republic, Scalable Capital, Smartbroker, JustTrade, Finanzen.net, BUX Zero, among others.

While critical for the neo-broker community, the internalization of retail order flow in the German equity market goes back to at least the peak of the dot.com bubble in the late 1990s.⁴ Today, the market is dominated by five retail market makers (RMMs) which operate several specialized trading venues. Several of these firms have emerged around Germany’s former regional stock exchanges, which had become largely redundant with the advent of electronic trading. Unlike the large US wholesalers (Citadel, Susquehanna, Virtu), RMMs in Germany typically do not act as market makers on PLOMs and their proprietary trading activity is focused on retail order flow.⁵ This simple business model

⁴For example, the German retail broker DAB began offering off-exchange trading with Lang & Schwarz in 1998. See https://en.wikipedia.org/wiki/DAB_BNP_Paribas.

⁵Some RMMs also provide execution services to smaller institutional clients in an agency capacity. However, these activities are very small.

enables us to cleanly identify the profitability of retail making making.

Traditionally, German retail brokers offer their customers a choice between sending their orders to PLOMs (exchanges or multilateral trading facilities) or RMM-affiliated venues. This does not mean that they do not receive any PFOF, since they may receive compensation for nudging clients towards particular venues, for example through default settings in the order entry form.⁶ However, several neo-brokers route their entire order flow to a single RMM, which implies significantly higher revenues from PFOF and enables them to charge low commissions.⁷ This has put pressure on incumbent brokers to increase their reliance on PFOF and route more order flow to RMMs (see Section 3.2).

3 Data and descriptive statistics

We first describe the data and then provide an overview of aggregate statistics.

3.1 Data

The main dataset used for our analysis consists of supervisory transaction-level data collected under the EU’s MiFID II framework since January 2018. However, we notice a number of reporting issues in the first months of the sample, and therefore only work with the data from July 2018 onwards. Our sample period ends in June 2021 and thus spans exactly three years. In the following, we describe the essential features of these data. Additional details can be found in the “Regulatory technical and implementing standards” published by the European Securities Markets Authority.⁸

⁶See “Wie Banken beim Aktienhandel doppelt abkassieren”, Wirtschaftswoche, 23 April 2015 (available in German only).

⁷These brokers typically designate a backup venue in case the RMM faces an outage.

⁸These are available at: https://www.esma.europa.eu/sites/default/files/library/2015/11/2015-esma-1464_annex_i_-_draft_rts_and_its_on_mifid_ii_and_mifir.pdf

The data cover all equity transactions for which the German securities markets regulator BaFin is the relevant “competent authority”, irrespectively of where the transaction takes place. This includes the near-universe of German stocks as well as a small number of foreign stocks that are listed and actively traded in Germany.⁹ In addition, the dataset also contains information on all equity transactions executed by legal entities registered in Germany, including trading in foreign stocks on foreign markets. Taken together, our dataset covers all trading in German stocks as well as *all* trading by German entities.

Each transaction record contains the key variables typically found in equity market datasets such as the ISIN code, price, quantity, currency, execution timestamp (rounded to the nearest second), and execution venue. In addition, the data also contain confidential information about the identity of the buyer and the seller for each transaction. While institutional counterparties are identified via their legal entity identifier (LEI), the identity of natural persons was masked by Bundesbank’s “Research Data and Service Centre” before making the data available to us. Accordingly, we can only identify whether a counterparty is a natural person, but it is not possible to follow individuals across stocks or over time.

We restrict our sample to the most liquid German stocks. To this end, we retrieve the historical constituents of the CDAX Index, which contains all German stocks from the two most liquid market segments (“General Standard” and “Prime Standard”). Throughout our sample period, a total of 457 stocks were part of this index at some point in time. We also download data for daily opening and closing prices as well as trading volume from Refinitiv Eikon. Finally, we obtain intraday quote data for a subset of these stocks

⁹One example for a foreign stock in the supervisory remit of Bafin is Qiagen N.V., a Dutch company originally founded in Germany that is part of the DAX30 blue chip index and predominantly traded on Xetra, Germany’s main stock market.

(members of the DAX and MDAX indices) from Refinitiv Datascope.

All five RMMs active in Germany internalize retail order flow through affiliated trading venues. We link trading venues (identified by a market identifier code, or MIC) and market makers based on public information on their websites. Moreover, we run random cross-checks to verify that the vast majority of the underlying order flow stems from natural persons or from retail brokers.

3.2 Aggregate developments

We first illustrate the aggregate developments of retail trading activity in the German equity market. [Figure 1](#) depicts the time series of retail trading volume and contrasts it with the activity on Deutsche Boerse’s Xetra platform, the primary market for German stocks. We observe that retail trading in Germany increases significantly over the sample period, and spikes during the Covid-19 lockdown periods in spring 2020 and winter 2020/21. Overall, retail trading has been edging up from around 400 million EUR per day at the beginning of the sample period to around 600 million EUR per day towards the end. At the same time, trading on Xetra has stayed largely constant (albeit a few swings) at close to 5 billion EUR per day. This means that the share of retail activity has increased from around 7% to more than 12%. The overall pattern is consistent with the widely-documented retail trading boom in the United States ([Ozik et al., 2021](#)).

Next, we look at the distribution of retail order flow across RMM-affiliated trading venues and other trading venues.¹⁰ [Figure 2](#) shows that the share of retail volume handled by RMMs has increased steadily over our sample period, from slightly below 40% at the

¹⁰For this comparison, we exclude retail trades that are marked as “XOFF”, since these cannot be attributed to a particular trading venue. These are typically so-called “give-up” trades between brokers and their retail clients, where the original trade was executed either with an RMM or in PLOMs.

beginning to close to 60% towards the end. This is consistent with the entry of multiple neo-brokers over the sample period and increased attempts by incumbents to feed off competition by nudging their own investors towards such venues in exchange for PFOF.

One important feature of RMM-affiliated venues is that they feature significantly longer trading hours than the PLOMs that are responsible for price discovery. Trading on Xetra, which dominates trading in German equities, takes place from 9:00-17:35 CET. We henceforth refer to this time window as “regular trading hours” (RTH). By contrast, the RMM-affiliated venues are typically open 8:00-22:00, which means they offer both pre-market (8:00-9:00) and after-hours trading (17:35 - 22:00).¹¹ We henceforth label the union of these two time periods as “outside regular trading hours” (OTH). [Figure 3](#) provides a decomposition of RMMs’ trading activity into RTH and OTH. We can see that OTH trading is an economically significant phenomenon, it oscillates between 10% and 20% of RMMs’ total trading during the sample. However, there is no clear trend over time.

4 Retail market making

[Table 1](#) provides a comprehensive overview of the trading activity of RMMs at the portfolio level. Like other intermediaries, RMMs trade in a broad array of securities, so that their activity and profitability is best assessed from a portfolio perspective. To comply with the Bundesbank’s confidentiality rules, we are only able to report the mean and standard deviations due to the small number of RMMs. Moreover, to ensure robustness against outliers, we winsorize measures of trading volume, net volume, revenue, and

¹¹There is one exception, which operates even longer from 7:30-23:00.

capital usage.¹²

Panel A shows that the average RMM-day is characterized by a trading volume of 122 million EUR, which is spread out over around 270 stocks. The average inventory ratio is below 1 percent, which suggests that RMMs carry very little overnight inventory, consistent with their focus on retail liquidity provision. More generally, RMMs tend to take relatively limited positions. Their capital usage, defined as the maximum intraday inventory position at the portfolio level, averages almost exactly 4 million EUR, or less than 4% of their average trading volume.

OTH trading accounts for close to 15% of the average RMM-day, and the number of traded stocks is significantly lower at around 186. Since PLOMs are closed by definition, RMMs are not able to engage in active inventory management when trading OTH. Accordingly, they exhibit an average inventory ratio of around 4.24%, compared to 0.91% during RTH. Note that there are some diversification effects between RTH and OTH trading due to imperfectly correlated order flow.

Panel B details how RMMs' trading activity is distributed across different trading venues. Slightly more than half of their trading volume is executed on their own venues, while lit exchanges account for 26.5% and off-exchange deals ("XOFF") sum up to 14.8%. Other trading venues (e.g. dark pools and systematic internalizers) account for less than five percent of RMMs' trading.

Taken together, these numbers suggest that RMMs frequently resort to other trading venues to manage the inventory risk arising from the market making activity on their own trading platforms. The fact that lit exchange volume accounts for more than a

¹²Variables with support over the real line are winsorized at the 1st and 99th percentile, while those with only positive support are winsorized at the 99th percentile. For variables that are the sum of two components (RTH + OTH), we first winsorize the individual components and then take the sum.

quarter of RMMs' trading is consistent with retail order flow not being perfectly balanced. Indeed, the aggregate absolute order imbalance on RMM-affiliated trading venues is close to 10% on the average RMM-day. This implies that a significant share of retail order flow ultimately ends up in PLOMs despite being executed with RMMs.¹³

These findings have implications for the potential effects of PFOF arrangements on market liquidity. A well-known concern is that PFOF may cause a deterioration of market liquidity because it directs uninformed order flow away from lit exchanges and therefore increases the adverse selection risk faced by liquidity providers. However, if RMMs redirect a significant share of this order flow back to lit markets, these effects could be attenuated.

We next turn to examine RMMs' profitability. As is customary in the literature (Menkveld, 2013; Baron et al., 2019), we compute trading revenues as the net cash flows accumulated during trading plus the mark-to-market value of the final position. Assuming a zero starting inventory, the revenue π from a total of N trades in a given stock are

$$\pi = \sum_{n=1}^N v_n(p^* - p_n), \quad (1)$$

where v_n denotes the signed quantity of the n -th trade, p_n is the corresponding transaction price, and p^* is the price at which any non-zero final position is marked to market. This equation can be interpreted as the market value of a position of $\sum_{n=1}^N v_n$ shares minus the cost of acquisition.

To deal with the fact that a substantial share of RMMs activity falls outside regular trading hours, we compute total RMM daily revenue as the sum of revenues accruing

¹³Several recent papers are interested in the *signed* order imbalance at the stock level, and have used it to explain returns. See, e.g. Boehmer et al. (2021) and Welch (2022).

during pre-market trading, regular trading hours, and after-hours trading. In the spirit of equation (1), we mark end-of-period positions to market using the next available exchange-determined price. That means we mark pre-market trading positions to the opening price, RTH trading to the closing price, and after-hours trading to the next day's opening price. Formally, trading revenues are given by

$$\pi^{total} = \underbrace{\sum_{k=1}^K v_k(p^o - p_k)}_{\pi^{pre}} + \underbrace{\sum_{l=1}^L v_l(p^c - p_l)}_{\pi^{RTH}} + \underbrace{\sum_{m=1}^M v_m(p^{o'} - p_m)}_{\pi^{after}}, \quad (2)$$

where K , L and M are the number of trades during pre-market, RTH, and after-hours trading, respectively, p^o and p^c denote the opening and closing price on the same day, and $p^{o'}$ is the next day's opening price. Finally, we define the trading revenue outside trading hours (OTH) as the sum of revenues from pre-market and after hours trading, $\pi^{OTH} = \pi^{pre} + \pi^{after}$.

We compute RMMs' revenues for each stock-day, and then sum over all traded stocks to obtain their revenues at the portfolio level. These are reported in [Table 2](#). The average RMM-day generates trading revenues of 36,710 EUR, with a standard deviation of approximately 48,600 EUR.

When looking at the breakdown into RTH and OTH trading, we can see that OTH revenues account for approximately half of the total. [Figure 4](#) shows that this is a very persistent phenomenon, with relatively little time-series variation. Since OTH trading only accounts for about 15% of RMM activity, this implies that it is vastly more profitable than RTH trading. To see this more directly, we also report revenues relative to trading volume. On the average RMM-day, RMMs earn 2.55 cents per 100 EUR traded, with a standard deviation of 2.01 cents. While RTH yields an average revenue of 1.62 cents,

OTH trading earns 9.99 cents. However, OTH trading is also considerably more risky with a standard deviation of 7.13 cents, relative to only 1.89 cents for RTH trading. This is consistent with the differences in inventory ratios reported in [Table 1](#) (Panel B). As RMMs cannot resort to other marketplaces for inventory management, liquidity provision during OTH is more risky and thus gives rise to more volatile revenues.

We also compute daily returns. These are obtained by dividing revenues by an estimate for the employed capital. We follow [Baron et al. \(2019\)](#) and approximate capital conservatively with an RMM's maximum inventory position (at the portfolio level) over the entire sample period. Based on this, we obtain an average daily return of 20.11 bps, with a standard deviation of 26.73 bps. Consistent with our results on revenues, we observe similar returns for OTH and RTH trading.

We examine the risk-return trade-off more closely in Panel B of [Table 2](#), where we compute Sharpe ratios at the firm level. We assume a zero risk-free rate, which has the advantage that the Sharpe ratio is independent of our measure of capital usage.¹⁴ Due to the low number of observations, we only report the cross-sectional mean and standard deviation. Based on their trading revenue, RMMs are extremely profitable, with an average Sharpe ratio of 17.85. While OTH trading offers a higher Sharpe ratio than RTH trading (17.16 vs. 14.37), the small sample size of five observations does not allow for any formal testing. However, the differences in terms of revenues are largely explained by differences in risk.

Finally, [Table 3](#) presents some key metrics for RMM activity and profitability at the RMM-stock-day level. Contrasting these to their portfolio-level equivalents in [Table 1](#) and [Table 2](#) provides some interesting insights regarding i) diversification effects as well

¹⁴As in [Baron et al. \(2019\)](#), this assumption is innocuous because short-term interest rates were slightly negative and essentially flat over the sample period.

as ii) differences across more and less active stocks. For brevity, we only comment on the main insights.

For example, the average inventory ratio at the RMM-stock-day level is 30%, compared to less than 1% at the portfolio level. This implies that RMMs are carrying significant inventory positions at the individual stock level (relative to stock-level trading volume), but these wash out almost completely at the portfolio level. We see similar effects in terms of capital usage. The average RMM-stock-day exhibits a capital usage of 50,310 EUR, which would sum up to almost 14 million EUR for an average of 270 stocks. This contrasts with less than 4 million of actual capital used for the average RMM-day at the portfolio level ([Table 1](#)).

We also find that the revenues from OTH trading exceed those from RTH trading, but they are reaped less frequently at the individual stock-level since there is a significant number of days with no OTH trading in less liquid securities. Moreover, we observe that the average trading revenue per EUR traded at the RMM-stock-day level is 25.51 cents, or ten times the average at the portfolio level. This indicates that trading in smaller stocks generates significantly larger profits.

5 Non-retail market-making: a benchmark

In this section, we examine the trading activity and profitability of non-RMM proprietary trading firms (PTFs) in the German equity market. The purpose is to obtain a benchmark for the profitability of RMMs. The idea behind this is simple. RMMs are proprietary trading firms who tend to pay brokers for the “privilege” of executing their retail order flow. Without these PFOF agreements, RMMs could alternatively operate similar to

other PTFs.

Our identification of PTFs closely follows [Baron et al. \(2019\)](#). We first search the data for members of the European Principal Traders Association (EPTA).¹⁵ We then manually screen the 200 most active entities for additional proprietary trading firms based on information provided on their webpage. We discard a small number of firms that self-report as being solely focused on derivatives trading.¹⁶ Moreover, we drop one firm due to data quality concerns because it reports a large number of off-exchange block trades with unrealistic transaction prices. This leaves us with a total of 21 PTFs.

[Table 4](#) provides an overview of PTFs self-reported trading activity. Panel A shows that trading volume on the average PTF-day is 156 million EUR, which is only slightly larger than the numbers for RMMs reported in the previous section. By contrast, the standard deviation is considerably higher, suggesting more significant variation across firms and/or over time. On average, PTFs trade 101 stocks per day, which is significantly lower than the 270 stocks traded by RMMs. This is natural because most PTFs are likely to be focused on high-frequency trading strategies that can only be implemented in sufficiently liquid securities. The average inventory ratio is 9.6 percent. While this is significantly higher than what we find for RMMs, it is considerably lower than the numbers reported by [Baron et al. \(2019\)](#). PTFs capital usage also corroborates the view that they take larger positions than RMMs. It averages 8.40 million EUR, which is about twice that of RMMs, while both groups exhibit comparable trading volumes. Overall, these numbers are consistent with PTFs largely acting as intermediaries.

¹⁵See <https://www.fia.org/epta/articles/fia-epta-membership>.

¹⁶Market making in derivatives naturally involves entering offsetting positions in the cash market. However, the resulting revenues from these positions are not necessarily representative of the firm's profitability, so that we prefer to exclude these entities. Adding them to the sample of PTFs does not affect our conclusions.

Panel B reports a breakdown of PTFs' activity across different types of trading venues. More than 85% of their trading activity occurs in PLOMs. Off-exchange trading accounts for slightly more than 6%, with other venues (including dark pools and systematic internalisers) accounting for the remainder. In sum, this is consistent with PTFs trading almost exclusively in transparent limit order markets.

We next turn to measures of PTFs' profitability, which we report in [Table 5](#). Since PTFs trade almost exclusively on PLOMs, we do not provide a breakdown into RTH and OTH (when those markets are closed by definition). Accordingly, any inventory is marked to the daily closing price. On average, PTFs earn 17.79 million EUR per trading day, which is about half of what RMMs earn on average. The standard deviation is 50.92 million EUR, suggesting that there is considerable variation across firms and/or over time.

When scaling revenues by trading volume, we find an average revenue of 3.82 cents per 100 EUR traded. This is about 60% larger than 2.55 cents reported for RMMs in [Table 2](#). The difference becomes even more pronounced when comparing it to RMMs revenues during RTH, which is the time window during which PTFs do essentially all their trading.

By contrast, the average daily PTF return is 6.03 bps, and therefore is considerably below the 20.11 bps earned by RMMs over the entire day, or the 9.81 bps earned during RTH. The discrepancy between revenue per EUR traded and returns is easily explained by the differential use of capital. PTFs appear to exhibit more volatile positions, which use up more capital and therefore generate lower returns.

Panel B looks more closely at the risk-return trade-off for the 21 PTFs in our sample. The average annualized Sharpe ratio is 7.42, with a cross-sectional standard deviation of 7.72. This suggests that PTFs are highly profitable on a risk-adjusted basis, and our

numbers are broadly consistent with findings reported elsewhere. For comparison, [Baron et al. \(2019\)](#) report an average Sharpe ratio of 4.16 (with a standard deviation of 6.58) for 16 PTFs in the Swedish equity market, and [Menkveld \(2013\)](#) finds a Sharpe ratio of 7.62 for a large market maker in Dutch equities.

While PTFs earn very attractive Sharpe ratios, they pale in comparison with those earned by RMMs ([Table 2](#)), who are more than twice as profitable on a risk-adjusted basis. This even continues to be true when restricting RMMs to their revenues earned during RTH. Accordingly, retail market making is vastly more profitable (on a gross basis) than similar activity in PLOMs.

As in the previous section, we also report some of the key activity and profitability metrics at the PTF-stock-day level. These are summarized in [Table 6](#), and the resulting insights are similar to the case of RMMs. On average, PTFs exhibit individual stock-level inventories of around 32%, compared to around 10% at the portfolio level. We see qualitatively similar effects in terms of capital usage. Similarly, the stock-level revenue by trading volume average 8.19 cents per 100 EUR traded, which is more than double the number when aggregating across all stocks. The fact that the difference is significantly less pronounced than for RMMs is not surprising, since we have already shown that PTFs only trade a more limited sets of stocks, so that cross-sectional variation in terms of liquidity is less pronounced.

6 The value of retail order flow

In this section, we provide a simple back-of-the-envelope calculation that aims to quantify the value of retail order flow. To this end, we take the perspective of a trading firm that

can either i) act as PTF in PLOMs, or ii) be an RMM. Since RMMs' earn higher risk-adjusted returns than PTFs, the value of retail order flow is then equal to the trading firm's willingness to pay for becoming an RMM.

Since we assume a zero risk-free rate, the level of capital drops out from the Sharpe ratio. Hence, a trading firm's willingness to pay for retail order flow, ϕ , must satisfy

$$\sqrt{252} \frac{\mu_{RMM} - \phi}{\sigma_{RMM}} = \sqrt{252} \frac{\mu_{PTF}}{\sigma_{PTF}} \quad (3)$$

or

$$\phi = \mu_{RMM} - \frac{\sigma_{RMM}}{\sigma_{PTF}} \times \mu_{PTF}, \quad (4)$$

where μ_i and σ_i denote the mean and standard deviation of daily revenues for trader group $i \in \{RMM, PTF\}$. Using the numbers in [Table 2](#) and [Table 5](#) (Panel B), we get

$$\phi = 36,710 - \frac{27,100}{30,630} \times 17,190 = 21,500 \quad (5)$$

This implies that a trading firm would be willing to pay up to 21,500 EUR per RMM-day for access to retail order flow. This amounts to almost 60% of RMM revenues. Given the average RMM-day trading volume of 121.63 million EUR, it corresponds to roughly 1.76 bps. With five RMMs and 252 trading days, it sums up to 27.1 million EUR per year on aggregate.

In principle, ϕ represents the cash lump sum that a monopolistic broker could extract from competitive RMMs as PFOF. However, since there is a significant level of concentration among both RMMs and brokerage firms (both in Germany and in the US), it appears reasonable that neither side has complete bargaining power. Accordingly, our estimate is

more likely to represent an upper bound.

Unfortunately, there are no disclosures for PFOF in Germany. Accordingly, we can only compare our estimates to public data from the United States under SEC Rule 606. (Bryzgalova et al., 2022) report that PFOF in US equities was 2.4 billion USD for the period 2020-2021, or 1.2 billion USD/year. While these numbers are very large compared to our estimate, data on stock market trading volumes helps to put things into perspective. According to the World Federation of Exchanges, on-book trading volume for NYSE, Nasdaq and CBOE Global Markets averaged 62.1 trillion USD/year over the period 2019-2021, compared to 1.6 trillion EUR for Deutsche Boerse.¹⁷ Hence, trading in US equities is about 33 times larger than in German stocks, based on an average EUR-USD exchange rate of 1.15. Moreover, the share of retail trading relative to the market total in the US appears to be significantly larger than in Germany. A recent Forbes article estimates it to be almost one quarter of US stock trading, while our estimates for Germany (Figure 1) are only about half of that.¹⁸ This would imply a multiple of 66, and thus correspond to $\phi = 1.56$ billion USD/year (based on the above exchange rate). This is reasonably close to the publicly available PFOF data mentioned above.

In the Online Appendix (Table OA.2), we illustrate how our findings vary with the outlier treatment. Our results are based on a relatively conservative approach where we winsorize the data at the 1% level. If we tighten our criteria (i.e. winsorize fewer observations), our findings become stronger. For example, winsorization at the 0.1% level implies an estimate for ϕ of 29,360 EUR per MM-day, an increase of around 37 percent. Conversely, a loosening of the criteria leads to lower estimates for ϕ . However, since the

¹⁷These numbers are available at: <https://www.world-exchanges.org/our-work/articles/2021-annual-statistics-guide>.

¹⁸See “Retail Trading Just Hit An All-Time High. Here’s What Stocks Are The Most Popular”, Forbes Magazine, 3 Feb 2023 (online).

mean revenues are largely unaffected by applying different winsorization levels, looser criteria would be difficult to justify.

7 Dissecting profitability differences - adverse selection

In this section, we dissect the profitability differences between RMMs and PTFs. We focus on the two traditional sources of dealer risk highlighted in the literature, namely adverse selection (Kyle, 1985; Glosten and Milgrom, 1985) and inventory risk (Stoll, 1978; Amihud and Mendelson, 1980).

7.1 Adverse selection risk

A widespread argument is that internalization is profitable because retail order flow exposes market makers to little adverse selection risk. To shed light on this issue, we analyze the effective spreads and its decomposition for RMMs' and PTFs' passive orders. We focus on stocks that are part of the DAX and MDAX indices, since these are traded by nearly all RMMs and PTFs, unlike the less liquid stocks. We obtain quote data for Deutsche Boerse's Xetra platform from Refinitiv Datascope and compute the midquote for each order book update. We then match each trade in our database to the most recent midquote.

The effective (half) spread for the τ -th order is given by

$$ES_{\tau} = d_{\tau} \cdot \frac{p_{\tau} - m_{\tau}}{m_{\tau}} \quad (6)$$

where $d_\tau \in \{-1, 1\}$ is the trade-direction indicator, p_τ is the transaction price, and m_τ is the prevailing midquote. Trades are signed using the [Lee and Ready \(1991\)](#) algorithm. The effective spread can be rewritten as the sum of the price impact and the realized spread, which are given by

$$PI_\tau = d_\tau \cdot \frac{m_{\tau+\Delta} - m_\tau}{m_\tau} \quad (7)$$

$$RS_\tau = d_\tau \cdot \frac{p_\tau - m_{\tau+\Delta}}{m_\tau}, \quad (8)$$

where $m_{\tau+\Delta}$ denotes the midquote after a time interval Δ has elapsed. We use an interval of 10 seconds, following the recent literature ([Baron et al., 2019](#)).

The price impact aims to capture the adverse selection risk that the market maker is exposed to, whereas the realized spread is an estimate of the market maker revenue (see [Foucault et al., 2013](#)). The underlying assumption is that the market maker closes out his position after 10 seconds at the then-prevailing midquote. While this a simplistic setting that is unlikely to reflect reality accurately, a higher price impact is indicative for market makers being subject to more adverse price movements following passive trades.

We compute all three measures for RMMs' passive executions on affiliated trading venues and all of PTFs' passive executions, and then compute equal- and value-weighted averages for each MM-stock-day. We then regress each of these variables on a constant and a dummy variable that is equal to one if the market maker is a PTF, and zero if he is an RMM. [Table 7](#) contains the resulting regression coefficients with standard errors double-clustered at the market maker level and stock level and increasingly stringent versions of fixed effects. Panel A reveals that PTFs post wider effective spreads, which is consistent with RMMs providing price improvements to retail investors. In our preferred

specification with stock-day fixed effects, RMMs charge an equal-weighted spread of 4.44 bps, which is about 25% lower than the 5.94 bps charged by PTFs (column 4). While the difference is highly economically significant, it is only marginally statistically significant with a t-statistic of 1.90. Moreover, in the Online Appendix ([Table OA.1](#)), we show that the price improvement is no longer statistically significant when computing value-weighted effective spreads.

So while there is some evidence of RMMs providing price improvement in the German equity market, it is rather weak. This is perhaps not too surprising. On the one hand, brokers have an incentive to ensure that their customers obtain execution quality that is no worse than what is available on PLOMs. On the other hand, brokers have an incentive to maximize PFOF, and the ability of RMMs to provide price improvement mechanically declines with the size of their PFOF to brokers (as discussed in [Levy, 2022](#)).

Importantly, best execution under MiFID remains principles-based and is not enforced on a trade-by-trade basis. This means that RMMs can execute individual trades at prices that are worse than the currently prevailing best bid and offer. Unlike in the United States, there is no consolidated tape and thus no “official” NBBO-equivalent.

[Kothari et al. \(2021\)](#) and [Levy \(2022\)](#) show that benchmarking US retail trades against the NBBO can be misleading because many on-exchange trades also receive price improvement relative to the NBBO. Since we benchmark RMM effective spreads against PTF effective spreads, we essentially compare off-exchange execution with on-exchange execution and thus avoid this issue. However, our estimates of price improvement may be subject to a bias introduced by the need to impute trade direction using the Lee-Ready algorithm.

When turning to the decomposition in Panels B and C, we can see immediately that

PTFs are subject to significant adverse selection risks, while RMMs are not. On an equal-weighted basis, the price impact of orders executing against RMM quotes is not distinguishable from zero when controlling for stock-day fixed effects, while PTFs suffer a price impact of 4.54 bps (Panel B, column 4). As a result, RMMs are able to earn significantly higher realized spreads (Panel C). Since these static measures assume a uniform and fixed investment horizon, one cannot map them directly to our estimates for intermediary revenues in [Table 2](#) and [Table 5](#). Nevertheless, they provide strong evidence that RMMs are not exposed to the risk of adverse selection, but at the same time are posting comparable bid-ask spreads. This can easily explain why their revenues exhibit a much more favourable risk-return trade-off than those of PTFs.

7.2 Inventory risk

Next, we analyze differences in inventory risk across RMMs and PTFs. Following [Hansch et al. \(1998\)](#) and [Korajczyk and Murphy \(2019\)](#), we estimate the speed of mean reversion in dealer inventories. For each stock i , day t and market maker m , we estimate the regression

$$\Delta I_\tau = \alpha + \kappa(I_{\tau-1} - \bar{I}) + \epsilon_\tau, \quad (9)$$

where I_τ is the market maker's inventory position (in shares) at the end of the τ -th intra-daily 15-minute interval, and $\Delta I_\tau \equiv I_\tau - I_{\tau-1}$. To ensure comparability across intermediaries, we focus on DAX and MDAX stocks traded during regular trading hours. In line with our analysis of revenues, we assume that market makers start the day with a zero inventory, which is also the assumed target (i.e. we set $\bar{I} = 0$). Note that the estimate $\hat{\kappa}$ has an associated inventory half-life (in minutes) of $HL(\hat{\kappa}) = 15 \frac{\ln(1/2)}{\ln(1+\hat{\kappa})}$.

The behaviour of market maker inventories arises from two components: i) the imbalance that arises from the absorption of customer order flow, and ii) the sum of offsetting trades that are used to prevent inventory positions from becoming too large. Accordingly, it is interesting to analyze whether any potential disparities in mean reversion between RMMs and PTF are driven by differences in i), ii), or both.

To shed light on this question, we decompose changes in market maker inventories into their passive and active components, i.e. $\Delta I_\tau = \Delta I_\tau^P + \Delta I_\tau^A$. For each trader, the passive (active) order flow is given by all passive (aggressive) order executions. We then estimate

$$\Delta I_\tau^P = \alpha^P + \kappa^P(I_{\tau-1} - \bar{I}) + \epsilon_\tau^P \quad (10)$$

$$\Delta I_\tau^A = \alpha^A + \kappa^A(I_{\tau-1} - \bar{I}) + \epsilon_\tau^A. \quad (11)$$

Notice that linearity implies $\hat{\kappa} = \hat{\kappa}^P + \hat{\kappa}^A$.

We estimate equations (9) - (11) for each market maker-stock-day by OLS and then proceed as in the previous subsection. We regress the resulting coefficient estimates, winsorized at the 1% level, on a constant and a dummy variable that is equal to one if the market maker is a PTF, and zero if he is an RMM. [Table 8](#) contains the results, with standard errors double-clustered at the market maker and stock level and increasingly stringent versions of fixed effects. Our discussion focuses on the numbers in column (4).

Panel A shows that RMMs' inventories exhibit a significantly faster mean reversion ($\hat{\kappa} = -0.48$) than those of PTFs ($\hat{\kappa} = -0.22$). The coefficient estimates imply an inventory half-life of 15.9 minutes for RMMs, compared to 41.8 minutes for PTFs. These results indicate that inventory risk is a key reason for PTFs' significantly more volatile trading

revenues documented in Section 5.

Panel B shows that part of the faster mean-reversion in PTF inventories is due to the different nature of customer order flows. The estimate for the passive component of mean reversion is $\hat{\kappa}^P = -0.16$ for RMMs, compared to $\hat{\kappa}^P = -0.09$ for PTFs. The difference is statistically significant at the 1% level. These results are consistent with retail order flow being more balanced on average than the rest of the market, which contributes to a faster mean-reversion of RMMs' inventories.

Finally, Panel C shows that also the active component of inventory mean reversion is significantly stronger for RMMs ($\hat{\kappa}^A = -0.32$) than for PTFs ($\hat{\kappa}^A = -0.13$). This suggests that RMMs are substantially more aggressive in offloading any imbalances in their customer order flow. These results may reflect a lower risk appetite or a lower level of capital (risk-bearing capacity). It is difficult to gauge whether this is the result of preferences, or rather due to less sophisticated business models that simply aim at minimizing risk.

Taken together, RMMs exhibit a significantly lower exposure to inventory risk than PTFs, consistent with our results on trading revenues in Sections 4 and 5. This stems from the combination of more balanced customer order flow and more active inventory risk management.

8 Conclusion

We have provided a comprehensive picture of the activity of specialized RMMs in the German equity market. We show that retail market making is vastly profitable, and exhibits a very favourable risk-return trade-off, especially when benchmarked against

other PTFs that act as intermediaries on PLOMs. Retail order flow is as a low-risk source of income for sophisticated intermediaries because it exposes them to reduced adverse selection and inventory risk.

We also provide a simple back-of-the envelope calculation where PFOF is simply the fixed cash amount that equates the Sharpe ratio of RMMs and PTFs. The resulting estimates for PFOF are reasonably close to numbers circulating in the press or other research papers.

Naturally, our findings provide validation to all those that are concerned about the adverse effects of PFOF arrangements on market quality. As uninformed order flow is siphoned away from PLOMs, adverse selection must increase and intermediaries demand higher compensation for the risks incurred. However, since RMMs are aggressive in maintaining a tight inventory, a substantial share of retail order flow flows back to PLOMs, which may limit some of the negative effects of order flow segmentation.

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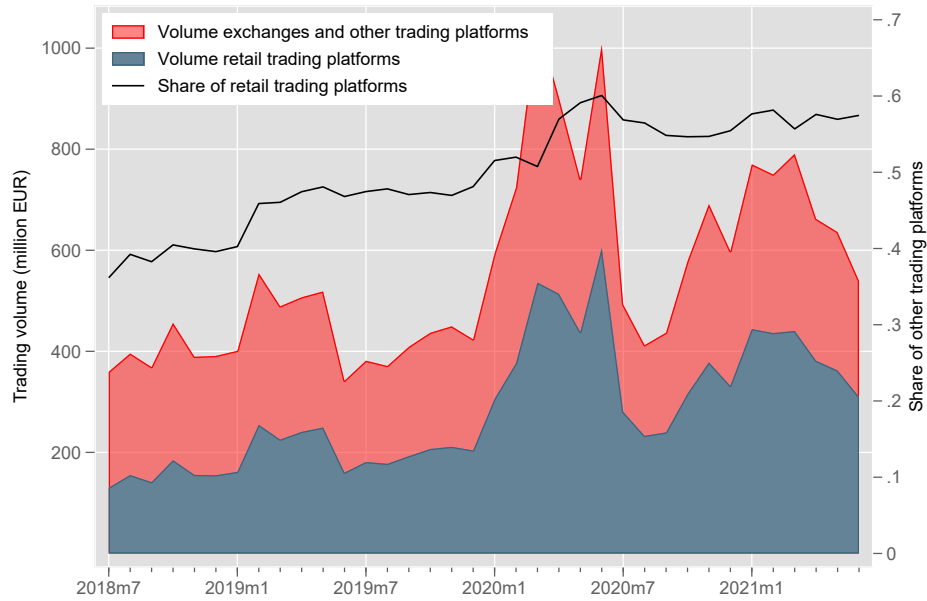
9 Tables and Figures

Figure 1: Retail trading volume relative to Xetra trading volume



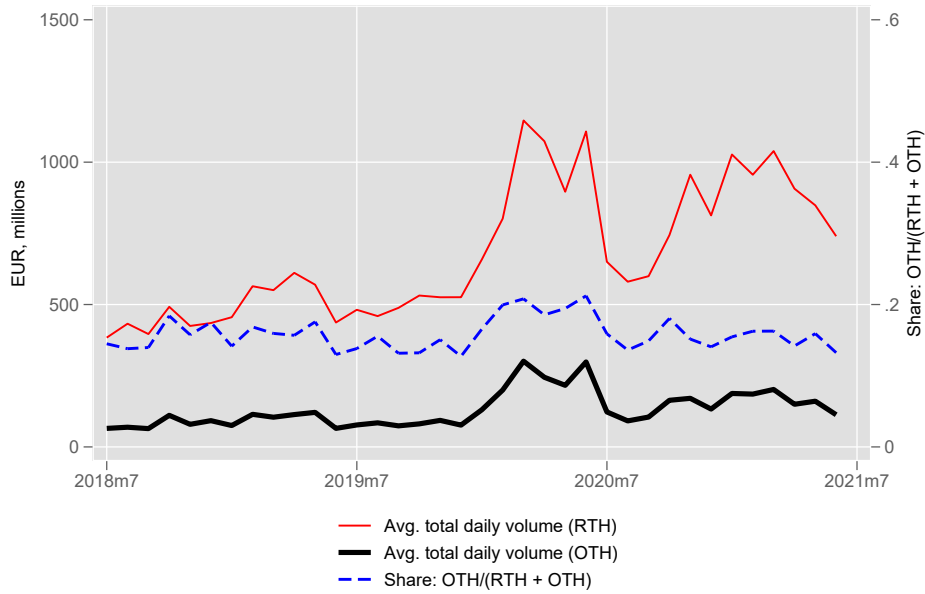
This figure illustrates the growth of retail trading in the German equity market over the sample period (July 2018 - June 2021). *Retail Volume* (thin red line, left axis) is the sum of all retail trading volume (in EUR, daily average for each month) that is executed in a trading venue (MIC code) other than “XOFF”. *Xetra Volume* (bold grey line, left axis) is the contemporaneous trading volume executed on Xetra. The dashed line (right axis) depicts their ratio.

Figure 2: Retail trading volume - regulated markets vs. retail trading platforms



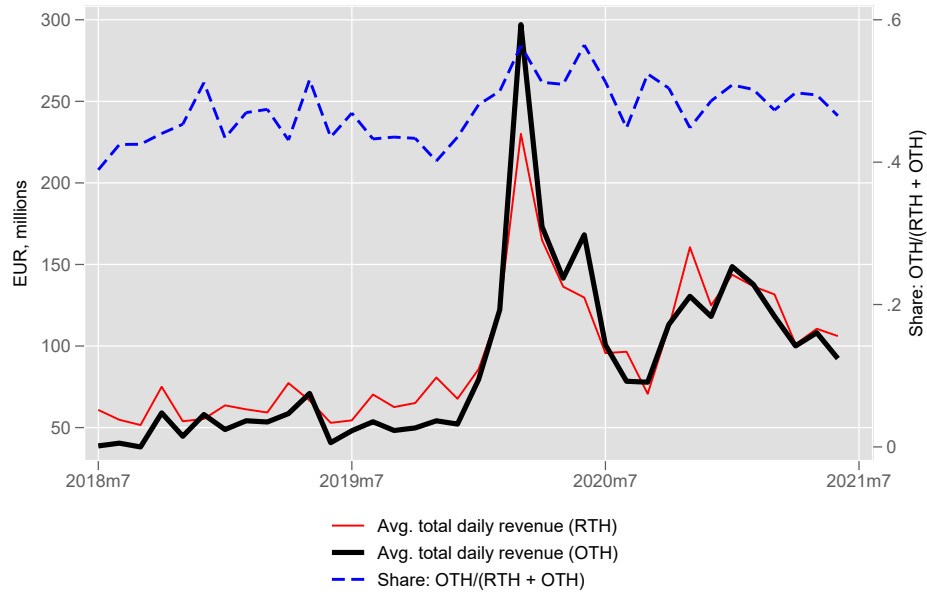
This figure illustrates the growth of retail trading in RMM-affiliated trading venues in the German equity market over the sample period (July 2018 - June 2021). *Volume retail trading platforms* (blue area, left axis) represents the sum of retail trading volume (in EUR, daily average for each month) executed in RMM-affiliated trading. *Volume exchanges and other trading platforms* (grey line, left axis) is the contemporaneous trading volume executed on in other venues (MIC codes) excluding “XOFF”. The solid black line (right axis) represents the share of RMM-affiliated venues.

Figure 3: RMM trading volume - RTH vs. OTH trading



This figure depicts the evolution of RMM trading volume in the German equity market during regular trading hours (RTH, thin red line) and outside trading hours (OTH, black bold line) for the sample period July 2018 - June 2020. Both series represent daily averages during the respective months (left axis). The dashed blue line (right axis) represents the share of OTH trading volume relative to total trading volume (RTH + OTH).

Figure 4: RMM revenue - RTH vs. OTH trading



This figure depicts the evolution of RMM gross trading revenues in the German equity market during regular trading hours (RTH, red bold line) and outside trading hours (OTH, black bold line) for the sample period July 2018 - June 2020. Trading revenues are computed following equation (2). Both series represent daily averages during the respective months (left axis). The dashed blue line (right axis) represents the share of OTH trading revenue relative to total trading revenue (RTH + OTH).

Table 1: RMM Activity

	N	Mean	St. Dev.
Panel A: Overall activity			
<i>Trading volume</i>	3,780	121.63	105.88
<i>Trading volume RTH</i>	3,780	95.34	70.44
<i>Trading volume OTH</i>	3,779	15.94	15.94
<i>#stocks</i>	3,780	270.65	45.00
<i>#stocks RTH</i>	3,780	258.33	48.39
<i>#stocks OTH</i>	3,779	185.62	68.32
<i>Inventory ratio</i>	3,780	0.59	0.61
<i>Inventory ratio RTH</i>	3,780	0.91	0.78
<i>Inventory ratio OTH</i>	3,779	4.24	4.19
<i>Capital usage</i>	3,780	3.98	13.72
Panel B: Venue breakdown			
<i>Pct. Own Venues</i>	3,780	54.27	27.30
<i>Pct. PLOMs</i>	3,780	26.50	15.09
<i>Pct. XOFF</i>	3,780	14.78	18.51
<i>Pct. Other</i>	3,780	4.45	2.97
<i>OI Own Venues</i>	3,780	9.39	9.43
<i>OI PLOMs</i>	3,780	17.99	14.49
<i>OI XOFF</i>	3,780	18.28	23.64
<i>Opp. Sign (Own, PLOMs)</i>	3,780	79.81	40.14
<i>Opp. Sign (Own, XOFF)</i>	3,780	72.20	44.81

This table contains summary statistics on RMMs' trading activity at the RMM-day level. Variables ending with RTH/OTH refer to variables computed during regular trading hours/outside trading hours, while the remaining variables refer to daily aggregates. *Trading volume* is the total EUR amount traded (in million EUR) across all securities. *#stocks* denotes the corresponding number of stocks with non-zero trading volume. *Inventory ratio* refers to the absolute value of the end-of-period inventory position (in EUR) divided by per-period total trading volume, expressed in percentage points. *Capital usage* is the daily maximum absolute inventory position in million EUR. *Pct. Own Venues* is the share of trading

volume that is executed in affiliated trading venues. *Pct. Exchanges*, *Pct. XOFF* and *Pct. Other* refer to the share of trading volume executed either in PLOMs, off-exchange (labelled as “XOFF”), and all remaining trading venues, respectively. *Pct. Own Venues*, *Pct. PLOMs* and *Pct. XOFF* denote the order imbalance for different sets of venues, calculated as the absolute value of buy volume minus sell volume divided by half of their sum, and expressed in percentage points. *Opp. Sign (Own, PLOMs)* is a variable that takes the value of 100 on RMM-days where the order imbalances in affiliated venues and PLOMs have opposite signs. *Opp. Sign (Own, XOFF)* is the same variable replacing PLOMs with trades labelled as “XOFF”.

Table 2: RMM profitability

	N	Mean	St. Dev.
Panel A: Profitability			
<i>Revenue</i>	3,780	36.71	48.60
<i>Revenue RTH</i>	3,780	18.84	27.33
<i>Revenue OTH</i>	3,779	17.87	23.90
<i>Revenue by Volume</i>	3,780	2.55	2.01
<i>Revenue by Volume RTH</i>	3,780	1.62	1.89
<i>Revenue by Volume OTH</i>	3,779	9.99	7.13
<i>Daily return</i>	3,780	20.11	26.73
<i>Daily return RTH</i>	3,780	9.81	15.00
<i>Daily return OTH</i>	3,779	10.30	13.85
Panel B: Risk vs. return			
<i>Mean revenue</i>	5	36.71	40.80
<i>Mean revenue RTH</i>	5	18.84	21.89
<i>Mean revenue OTH</i>	5	17.87	19.05
<i>St. Dev. revenue</i>	5	27.10	19.28
<i>St. Dev. revenue RTH</i>	5	16.75	10.19
<i>St. Dev. revenue OTH</i>	5	13.95	10.38
<i>Sharpe Ratio</i>	5	17.85	6.71
<i>Sharpe Ratio RTH</i>	5	14.37	7.28
<i>Sharpe Ratio OTH</i>	5	17.16	5.63

Panel A of this table contains summary statistics of RMM profitability measures at the RMM-day level. Variables ending with RTH/OTH refer to variables computed during regular trading hours/outside trading hours, while the remaining variables refer to daily aggregates. *Revenue*, *Revenue OTH* and *Revenue RTH* are daily gross trading revenues as defined in equation (2), and expressed in thousands of EUR. *Revenue by Volume* scales revenues by trading volume, as is expressed in basis points (cents per 100 EUR traded). *Daily return* is computed as revenues divided by estimated capital, which is defined as an RMM's maximum portfolio level position over the entire sample period, following [Baron et al. \(2019\)](#). Panel B reports measures for assessing the RMMs' risk-return tradeoff, computed at the RMM

level (N=5). *Mean revenue* and *St. Dev.Revenue* denote the time-series mean and standard deviation of RMMs' *Revenue* as computed in Panel A, expressed in million EUR. The Sharpe is given by an RMM's mean revenue divided by its standard deviation, and annualized by multiplication with $\sqrt{252}$.

Table 3: RMM activity and profitability at the RMM-stock-day level

	N	Mean	St. Dev.	P25	P50	P75
Panel A: Overall activity						
<i>Trading volume</i>	1,023,063	449.40	1,569.91	7.85	39.76	219.11
<i>Trading volume RTH</i>	976,486	369.05	934.10	7.50	37.56	203.71
<i>Trading volume OTH</i>	701,476	85.87	215.21	2.83	11.41	50.75
<i>Inventory ratio</i>	1,023,063	29.80	37.06	1.66	10.00	49.42
<i>Inventory ratio RTH</i>	976,486	31.98	37.97	2.09	11.72	57.79
<i>Inventory ratio OTH</i>	701,476	52.17	40.26	11.30	45.49	100.00
<i>Capital usage</i>	1,023,063	50.31	94.24	4.29	14.18	46.74
Panel B: Profitability						
<i>Revenue</i>	1,022,217	135.74	693.94	-24.00	8.30	129.52
<i>Revenue RTH</i>	976,486	72.93	600.35	-36.10	2.85	95.65
<i>Revenue OTH</i>	698,976	96.63	344.95	-2.00	11.78	83.60
<i>Revenue by Volume</i>	1,022,217	25.51	1,044.47	-5.79	2.14	23.78
<i>Revenue by Volume RTH</i>	976,486	20.83	1,106.47	-8.23	0.91	20.38
<i>Revenue by Volume OTH</i>	698,976	40.94	559.33	-2.27	11.80	52.44

This table contains summary statistics on RMMs' trading activity and profitability at the RMM-stock-day level. All variables are defined as in [Table 1](#) and [Table 2](#). *Trading volume* and *Capital usage* are expressed in thousands of EUR. *Revenue* is expressed in EUR.

Table 4: PTF Activity

	N	Mean	St. Dev.
Panel A: Overall activity			
<i>Trading volume</i>	13,996	156.25	274.87
<i>#stocks</i>	13,996	100.90	73.86
<i>Inventory ratio</i>	13,996	9.56	17.88
<i>Capital usage</i>	13,996	8.40	21.78
Panel B: Venue breakdown			
<i>Pct. PLOMs</i>	13,996	85.09	26.36
<i>Pct. XOFF</i>	13,996	6.34	14.82
<i>Pct. Other</i>	13,996	8.56	21.21

This table contains summary statistics at the PTF-day level. *Trading volume* is the total EUR amount traded (in million EUR) across all securities. *#stocks* denotes the corresponding number of stocks with non-zero trading volume. *Inventory ratio* refers to the absolute value of the end-of-period inventory position (in EUR) divided by per-period total trading volume, expressed in percentage points. *Capital usage* is the daily maximum absolute inventory position in million EUR. *Pct. PLOMs* is the share of trading volume that is executed in PLOMs, while *Pct. XOFF* and *Pct. Other* refer to the share of trading volume labelled as “XOFF” or all other remaining trading venues, respectively.

Table 5: PTF profitability

	N	Mean	St. Dev.
Panel A: Profitability			
<i>Revenue</i>	13,996	17.79	50.92
<i>Revenue by Volume</i>	13,996	3.82	22.38
<i>Daily return</i>	13,996	6.03	13.09
Panel B: Risk vs. return			
<i>Mean revenue</i>	21	17.19	31.49
<i>St. Dev. revenue</i>	21	30.63	26.74
<i>Sharpe Ratio</i>	21	7.42	7.72

Panel A of this table contains summary statistics of PTF profitability measures at the PTF-day level. remaining variables refer to daily aggregates. *Revenue* denotes daily gross trading revenues as defined in equation (2), and expressed in thousands of EUR. *Revenue by Volume* scales revenues by trading volume, as is expressed in basis points (cents per 100 EUR traded). *Daily return* is computed as revenues divided by estimated capital, which is defined as a PTF's maximum portfolio level position over the entire sample period, following [Baron et al. \(2019\)](#). Panel B reports measures for assessing the PTFs' risk-return tradeoff, computed at the PTF level (N=21). *Mean revenue* and *St. Dev. Revenue* denote the time-series mean and standard deviation of PTFs' *Revenue* as computed in Panel A, expressed in million EUR. The *Sharpe Ratio* is given by a PTF's mean revenue divided by its standard deviation, and annualized by multiplication with $\sqrt{252}$.

Table 6: PTF activity and profitability at the PTF-stock-day level

	N	Mean	St. Dev.	P25	P50	P75
Panel A: Overall activity						
<i>Trading volume</i>	1,412,249	1,548.47	4,549.13	13.89	85.68	705.82
<i>Inventory ratio</i>	1,412,249	32.01	38.52	0.99	11.27	59.99
<i>Capital usage</i>	1,412,249	179.73	462.73	6.86	28.76	123.56
Panel B: Profitability						
<i>Revenue</i>	1,412,249	176.32	2,379.54	-67.50	8.80	197.75
<i>Revenue by Volume</i>	1,412,249	8.19	103.09	-8.28	1.94	19.75

This table contains summary statistics on RMMs' trading activity and profitability at the RMM-stock-day level. All variables are defined as in [Table 4](#) and [Table 5](#). *Trading volume* and *Capital usage* are expressed in thousands of EUR. *Revenue* is expressed in EUR.

Table 7: Effective spreads and decomposition - RMMs vs. PTFs

	(1)	(2)	(3)	(4)
Panel A: Effective spread				
<i>Intercept</i>	4.57*** (11.60)	4.36*** (14.28)	4.40*** (13.98)	4.44*** (13.85)
<i>PTF</i>	1.30 (1.59)	1.62* (1.94)	1.57* (1.89)	1.50* (1.90)
Panel B: Price impact				
<i>Intercept</i>	0.25* (2.03)	0.13 (0.74)	0.15 (0.85)	0.19 (1.10)
<i>PTF</i>	4.45*** (9.72)	4.63*** (9.64)	4.61*** (9.73)	4.54*** (10.22)
Panel C: Realized spread				
<i>Intercept</i>	4.30*** (10.06)	4.20*** (11.17)	4.22*** (11.09)	4.23*** (11.04)
<i>PTF</i>	-3.15*** (-5.48)	-3.00*** (-5.26)	-3.03*** (-5.28)	-3.04*** (-5.41)
Fixed effects	day	stock	stock & day	stock-day
Clustering	MM & stock	MM & stock	MM & stock	MM & stock

This table presents coefficient estimates from the regression equation

$$y_{i,t,m} = \alpha + \beta PTF_m + \epsilon_{i,t,m},$$

where $y_{i,t,m}$ denotes a measure of market quality for stock i on day t and market maker m . In Panel A, the dependent variable is the effective spread, whereas it is the 10-second price impact in Panel B, and the realized spread in Panel C. These variables are defined in equations (6)-(8) in the main text. All variables are computed as equal-weighted averages across all relevant trades on the same day and stock by the same market maker. For RMMs, we consider all passive executions on own trading venues, and for PTFs we base calculations on all passive execution across all venues. The different columns correspond to different fixed effects specifications with increasing stringency: from day and stock fixed effects in

columns (1) and (2), to stock and day fixed effects in column (3) and stock-day fixed effects in column (4). Standard errors double-clustered at the market maker and stock level are given in parentheses. One, two and three asterisks represent statistical significance at 10%, 5% and 1% respectively.

Table 8: Inventory risk - RMMs vs. PTFs

	(1)	(2)	(3)	(4)
Panel A: Mean reversion coefficient (κ)				
<i>Intercept</i>	-0.48*** (-21.59)	-0.47*** (-22.04)	-0.47*** (-21.89)	-0.48*** (-20.51)
<i>PTF</i>	0.26*** (11.04)	0.26*** (11.53)	0.26*** (11.16)	0.26*** (10.22)
Panel B: passive component (κ^P)				
<i>Intercept</i>	-0.16*** (-9.86)	-0.16*** (-9.60)	-0.16*** (-9.54)	-0.16*** (-9.83)
<i>PTF</i>	0.07*** (3.15)	0.07*** (3.21)	0.07*** (3.06)	0.07*** (3.18)
Panel C: active component (κ^A)				
<i>Intercept</i>	-0.31*** (-9.51)	-0.31*** (-9.70)	-0.31*** (-9.60)	-0.32*** (-9.28)
<i>PTF</i>	0.19*** (5.15)	0.19*** (5.39)	0.19*** (5.19)	0.19*** (5.11)
Fixed effects	day	stock	stock & day	stock-day
Clustering	MM & stock	MM & stock	MM & stock	MM & stock

This table presents coefficient estimates from the regression equation

$$y_{i,t,m} = \alpha + \beta PTF_m + \epsilon_{i,t,m},$$

where $y_{i,t,m}$ denotes a measure of inventory mean reversion for stock i on day t and market maker m . In Panel A, the dependent variable is the mean-reversion coefficient κ , whereas it is the passive component κ^P in Panel B, and the active component κ^A in Panel C. The variables are the resulting estimates from regressions (9)-(11) in the main text. All variables are estimated from daily regressions at the 15-minute frequency. For RMMs, we consider all passive executions on own trading venues, and for PTFs we base calculations on all passive execution across all venues. The different columns correspond to different fixed effects specifications with increasing stringency: from day and stock fixed effects in columns (1) and (2),

to stock and day fixed effects in column (3) and stock-day fixed effects in column (4). Standard errors double-clustered by market maker and stock level are given in parentheses. One, two and three asterisks represent statistical significance at 10%, 5% and 1% respectively.