



# Impact of the Dark Rule Amendments

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*Trading Review and Analysis*

*Investment Industry Regulatory Organization of Canada*

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## 1. Executive Summary

On October 15, 2012, following a lengthy industry consultation by the Canadian Securities Administrators (CSA) and the Investment Industry Regulatory Organization of Canada (IIROC), IIROC implemented a dark liquidity framework. Amendments to the Universal Market Integrity Rules (UMIR) required that small orders which interact with dark must receive meaningful price improvement, and lit orders must trade before dark orders at the same price on the same marketplace. The regulatory objective of this change was to establish a framework that recognized the contribution of dark orders to the post-trade price discovery process and their value to certain investors, while balancing this against the need to protect lit market price discovery, ensure meaningful price improvement and establish a level playing field between transparent marketplaces and dark pools. In introducing this new regulatory framework, IIROC recognized there might be a cost to certain trading segments; however, the policy was proactive in protecting the integrity of the price discovery process.

We analyze the impact of the rule change on the Canadian equity markets and conclude that on balance, IIROC met its objective with minimal impact to market quality. The majority of liquidity measures show no significant impacts to the security groups analyzed. As expected while overall market depth was not impacted, there was an improvement in lit market depth for both TSX Composite securities and Exchange Traded Funds (ETFs) at the national best bid/offer (NBBO). Price efficiency measures show mixed results; return autocorrelation shows significant deterioration whereas volatility shows no change. Trading groups such as active retail are impacted by the rule change in terms of increased transaction costs<sup>1</sup>; however, the retail group as a whole does not experience a significant deterioration. This redistribution of benefits/costs is a logical consequence of the rule change. While IIROC had expectations that some measures might improve, such as quoted spreads, this was not an explicit policy goal.

We analyze the impact of the dark rule amendments in three main parts:

1. The relative changes in dark to lit trading as well as market share shifts amongst trading venues.
2. Impact to market quality as measured by spreads, flow of benefits/costs amongst different trading segments, market depth, volatility, auto-correlation of returns and diversity in liquidity provision.
3. Use of dark trading venues by brokers to internalize their order flow. In this we look at trades between a broker and a client of a broker which were not intentional crosses, and met on a marketplace. We report aggregate levels of market-met internalization (MMI), but also focus on changes in composition and behavior of the top principal traders involved in MMI in the dark.

Overall levels of dark trading decrease dramatically concurrent with the rule change as can be seen in Figure 1. Alpha Exchange Inc. (ALF) and MATCH Now (TCM), which had offered price improvement in the dark but did not meet the new requirement, were required to change their models to comply with UMIR. Of these two marketplaces, the ALF dark trading facility, IntraSpread, experiences the largest impacts to dark trading values as a result of the dark rule amendments. The majority of trading in the

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<sup>1</sup> As measured by effective spreads, and not including marketplace fees.



dark prior to the rule was in the constituents of the TSX Composite index and in highly-liquid ETFs, as seen in Figure 2, and our analysis is largely focused on these two groups of securities.

Our observation of market quality measures show mixed results with most measures showing no significant impact with the exception of a deterioration in return autocorrelation measuring price efficiency.

With respect to overall market liquidity measures, we see no statistically significant deterioration in market quality as measured by time-weighted average spreads (TWAS), effective spreads and realized spreads.

We further explore effective and realized spreads and investigate how costs and benefits are divided among trading segments. Of particular interest is the retail group, which benefits from price improvement in dark markets in the pre period and which subsequently moves to the lit markets. While we find active retail flow experiences moderately significant increased transaction costs (as measured by effective spreads) in the post period, the total retail flow, active and passive combined, does not show increased costs. The benefits, on the other hand, largely accrue to high frequency passive liquidity providers.

We see an increase in market depth in the lit at the NBBO for both the TSX Composite and the highly liquid ETFs; market depth in the highly liquid ETFs also increased one level deep. In the dark, we observe a decrease in market depth at all levels for both the TSX Composite and the highly-liquid ETFs which was expected. When dark and lit are combined, market depth at both the top of book and at deeper levels show no change as a result of the dark rule change for either TSX Composite securities or the highly liquid ETFs.

We find that liquidity provisioning becomes more diversified in the dark markets for TSX Composite securities in the post period. This is unsurprising as the dark market models revert to one where there is less intermediation and more meeting of natural flows. However, we find that lit markets for TSX Composite securities become more concentrated (less diversified) as dominant liquidity-providing entities shift additional trading activity to lit markets. In the case of ETF securities, dark markets become more concentrated and we do not see any significant change in lit markets.

This is further validated by reviewing top liquidity providers in each market. We find that most of the top dark liquidity providers are diversified across lit and dark markets in the pre period and in the post period shift and increase their activity in the lit markets. One trader's activity is a notable exception. This trader, the largest liquidity provider in the dark prior to the rule change, trades primarily in the dark in the pre period, and largely ceases to trade in the dark or lit in the post period.

We also measure mid-quote return autocorrelation at different lags and see consistent and statistically significant results indicating deterioration in informational efficiency in the TSX Composite. ETFs show no change in informational efficiency.



We measure volatility at different frequencies and observe no significant changes that are robust or consistent.

Finally we investigate the use of dark markets and order types by brokers to internalize their retail order flow in the pre period and the effect of the rule change on this activity. We find that MMI decreases very significantly following the implementation of the dark rule amendments. While overall levels of such activities are very low to begin with (2.75%<sup>2</sup> of total volume), we note a concentration of MMI in the pre period by one particular broker in the TSX Composite on IntraSpread. A few brokers exhibit similar MMI activity on IntraSpread in the highly-liquid ETFs. The overall decrease in MMI in the post period is driven by a few brokers who reduce their liquidity provisioning on IntraSpread.

In addition to concluding that IIROC's objectives are achieved with minimal impact to market quality, the current study sheds some light on the impact of certain aspects of Canadian market structure. Arguably the beneficial aspects of the pre-rule market structure (lower effective spreads for retail) were less to do with dark trading and more the result of market structure that allows for effective segregation of active retail flows, trades within the spread in tick-constrained stocks, and a liquidity provider's control over who they trade with. These are important considerations as the Canadian market continues to evolve, as new marketplaces are created and existing marketplaces respond to changes.

## 2. Background

### i. Regulation

The dark rule amendments, implemented on October 15, 2012, were the result of a lengthy consultation process with the investment industry by the CSA and IIROC. This process began in October 2009 when IIROC and the CSA jointly published *Consultation Paper 23-404 – Dark Pools, Dark Orders, and Other Developments in Market Structure in Canada* (CSA and IIROC 2009) and requested comments from the investment industry. Some of the concerns brought forward for comment included:

- Dark pools and dark order types might affect the price discovery process by not revealing the depth and breadth of some orders.
- Internalization of order flow by large dealers in Canada could significantly reduce liquidity in the visible markets and threaten the price discovery mechanism.
- Dark orders receive the advantage of price discovery in lit markets without contributing to the process, which might be perceived as unfair.

On April 13, 2012, IIROC published a Notice of Approval concerning provisions respecting dark liquidity (IIROC 2012). The amendments:

- ensure that visible orders on a marketplace execute before dark orders on that marketplace at the same price;

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<sup>2</sup> A more meaningful proportion of retail flows were internalized (8.2% of the TSX Comp and 8.9% of HL ETFs)



- require dark orders to provide a better price, except when executing with large orders which are either larger than 50 standard trading units or have a value above \$100,000; and
- require that a better price be at least one trading increment and, when the displayed market has a spread of only one trading increment, at least one-half of a trading increment.

The objective of these changes was to incentivize lit markets over dark markets in the absence of meaningful price improvement and establish a fair and consistently applied definition of price improvement, while acknowledging the contribution of dark orders to the post-trade price discovery process and their value to certain investors. In drafting the dark provisions, IIROC took into account IOSCO's Principles on Dark Liquidity (IOSCO 2011).

## **ii. Related Work**

Our work is closely related to academic work by Foley and Putniņš, which lays out a methodology for measuring the impact of the dark rule amendments (Foley and Putniņš 2014; Foley and Putniņš 2015). The papers also outline related academic work and provide an informative discussion on the expected impact. More specifically, Foley and Putniņš note that the distinction between different types of dark activity in a particular market is important in predicting policy outcomes. Foley and Putniņš distinguish between one-sided and two-sided dark trading, which they define as follows: One-sided dark trading occurs at a single (midpoint) price; two-sided dark trading occurs at non-midpoint prices. Foley and Putniņš note that profitable market-making strategies are only possible when using two-sided dark trading. They conclude that two-sided dark trading, in moderate levels, lowers quoted, effective and realized spreads, and improves informational efficiency. They find no evidence that midpoint dark trading has an effect on market quality. Their literature review shows that previous studies on the subject produces mixed results, however, there is support to suggest that two-sided trading is beneficial in terms of finding price improvement in tick-constrained securities and potentially forcing more competition in dark liquidity provisioning (with a spill-over effect on lit markets).

A recent IIROC-sponsored study (independent of this work) also investigates the impact of dark trading in Canada using the same IIROC dataset with some data masked (Comerton-Forde, Malinova and Park 2015). This study focuses on highly-liquid interlisted securities and the impact of the dark rule amendments on market liquidity and efficiency on a market-wide basis as well as on individual trading groups. In their final analysis, they distinguish between liquidity-providing traders in the dark who are one-sided (building or unwinding positions) or two-sided (making markets and capturing the bid-ask spread), and conclude that the effect of the dark rule amendments on a marketplace depends upon the type of liquidity provision used. Comerton-Forde, Malinova and Park further report no changes to price efficiency, little evidence of change to trading costs to individual trading groups or overall, and increases to lit market depth.

We build upon existing current work by:

- Utilizing a rich dataset that includes all visible and dark markets in Canada.
- Viewing market depth at deeper levels of both the lit limit book and dark markets.



- Extending the analysis beyond TSX Composite securities to highly-liquid ETFs. This is especially important considering the concentration of retail trading in these securities as well as the concentration of impact as seen in Figure 2.
- Investigating in a more granular way the occurrence of market-met client principal trading as well as behavior of key liquidity providers in both dark and lit markets.

### iii. Trading Venues and Order Types

Canadian markets have a spectrum of pre-trade transparency ranging between fully lit and fully dark, and including lit marketplaces with dark order types. When lit and dark order types interact, the resulting trade is considered dark. The following table describes the marketplaces extant during the period of our study.

Table 1: Transparency of Canadian Marketplaces

Market	Transparency
Alpha Exchange Inc. (“ALF”)	Lit with Dark facility - IntraSpread
CNSX Markets Inc. – Canadian National Stock Exchange (“CNSX”)	Lit
Chi-X Canada ATS Limited (“CHX”)	Lit with Dark Order Types
Instinet Canada Cross Ltd. (“ICX”)	Dark
Liquidnet Canada (“LIQ”)	Dark
TriAct Canada Marketplace LP – MATCH Now (“TCM”)	Dark
Omega ATS (“OMG”)	Lit
CNSX Markets Inc. – Pure Trading (“PTX”)	Lit
TMX Group Inc. – TMX Select (“TMS”)	Lit
TMX Group Inc. – Toronto Stock Exchange (“TSX”)	Lit with Dark Order Types
TMS Group Inc. – TSX Venture Exchange (“TSXV”)	Lit with Dark Order Types

Only two marketplaces, ALF and TCM, had models which needed to be changed as a result of the dark amendments. Specifically, ALF and TCM offered price improvement which did not meet the new definition of “better price”. The other Canadian marketplaces were already in compliance with the dark rule amendments.

#### ALF

In June 2011, ALF, a lit marketplace, introduced IntraSpread, a dark trading facility. Active “Seek Dark Liquidity” (SDL) orders, which are restricted to retail clients, can interact with passive resting liquidity. Passive dark orders entered on IntraSpread can be directed to interact only with incoming active SDL orders. Prior to the Dark Amendments, SDL was a dark order type that would trade with resting dark liquidity in IntraSpread, receiving price improvement of 10% or 50% over the NBBO. If there was no dark liquidity, the SDL order would be returned to the Participant to be re-routed to a lit market. Following the Dark Amendments, SDL orders receive price improvement of 50% of the NBBO in IntraSpread. If there is no dark liquidity in IntraSpread, the SDL order will move to the ALF lit book to interact with liquidity there.





TCM

TCM, a fully dark marketplace, has two main order types; liquidity-providing (LP) orders and Marketflow orders. In contrast to IntraSpread, both types of orders are available to all types of market participants. Trades occur on TCM in two ways: via a randomized call market<sup>3</sup> between two LP orders, or immediately between an LP order and a Marketflow order. Prior to the dark rule amendments, if there was passive liquidity available, a Marketflow order would trade immediately, receiving 20% price improvement over the NBBO. Following the dark rule amendments, Marketflow orders trade immediately, receiving 50% price improvement over the NBBO. If there is no liquidity to trade with, the Marketflow order will be returned to the Participant to be re-routed to a lit market.

Table 2: Characteristics of TCM and IntraSpread

Characteristic	TCM	IntraSpread
Dark	Yes	Yes
Segregation	No – Marketflow and LP orders available to all market segments	Yes – active SDL orders only available to retail traders
Intra-spread Pricing	20% and 50%	10% and 50%
Liquidity provider trades with liquidity provider	Optional – LP can choose to interact with Marketflow only, or with all (LP and Marketflow)	Optional – Liquidity provider can choose to interact with passive dark only, SDL only, or both

As can be seen in Table 2, IntraSpread and TCM are similar in being dark venues which offer pricing within the NBBO and which allow liquidity providers to opt out of transacting with other liquidity providers; however, they are different with respect to segregation. As a result of these features, both TCM and IntraSpread are able to support a two-sided market-making model in the dark<sup>4</sup>. IntraSpread’s restriction of active order flow to retail clients has further implications, which we explore in detail in later sections.

#### iv. Internalization of Order Flow

As part of this study, we are interested in the circumstances in which a broker takes the other side of their client’s trade, and how this relates to the dark rule amendments. Specifically, trades between a client account and an inventory account from the same broker which meet in the market are captured in our measurement of MMI. Certain elements of market structure in the pre period facilitated MMI.

First, broker preferencing, in which orders by the same broker trade in preference to other orders at the same price which have time priority<sup>5</sup>, is allowed in Canada. In these types of trades, no price improvement is required in the lit markets as the orders meet in the market.

<sup>3</sup> Matches between passive liquidity orders take place every 5 seconds randomized by +/- 2 seconds. Trades take place at 50% of the NBBO.

<sup>4</sup> However, Comerton-Forde, Malinova and Park (2015) find that trading on ALF is dominated by two-sided market makers, whereas trading on TCM is not.

<sup>5</sup> Broker preferencing is offered by a marketplace. CHX, OMG and TMS do not support broker preferencing.



Second, TCM and IntraSpread offered pricing both at the midpoint (50%) and between the midpoint and the NBBO (20% of the spread on TCM and 10% of the spread on IntraSpread) in the pre period. Non-midpoint pricing appears to be an important element of profitable market-making.

Third, IntraSpread and TCM allow liquidity providers to restrict their liquidity provision to active orders. Both markets are therefore able to support a two-sided market-making model in the dark.

Fourth, IntraSpread allows only retail traders to submit active orders. In contrast, TCM allows all types of traders to submit active Marketflow orders.

From a review of these elements, we can see that in the pre period, IntraSpread offers the richest opportunities for systematic MMI, where inventory accounts make markets for an exclusively retail flow for 90% of the spread (rather than 100% of the spread). While it would not be possible for a broker to guarantee that their client flow would interact with their own principal flow, extensive active and passive participation on IntraSpread or TCM would likely result in a meaningful portion of MMI.

Other jurisdictions have other mechanisms and rules in place regarding internalization. In the US, retail flow is often internalized through the mechanism of “payment for order flow”, in which the dealer’s small retail orders are sold to a wholesale OTC market maker. The OTC market maker will trade with the orders at a price equal to or better than the NBBO (Preece and Rosov 2014). The dealer earns a fee and does not incur any risk (Weaver 2011). In the US, it is estimated that the majority of all marketable retail order flow is internalized (Preece 2012).

Australia has approximately 20 dark pools and crossing systems (dark pools operated by market participants). Eight of the crossing systems conduct client-principal trading – on these systems, client-principal trading represents 38% of the value traded (ASIC 2013). In May 2013, Australia instituted price improvement rules requiring price improvement for below block-size trades. Foley and Putniņš provide a comparative analysis of the impact of these rules on the Australian and Canadian markets (2014).

For the purpose of this report, we are interested in observing how levels of MMI changed following the dark rule amendments. Canadian rules effectively prohibit the payment for order flow model employed in the US. By requiring meaningful price improvement, the dark rule amendments reduced opportunities for brokers to benefit from market-making activities when trading with segregated retail flow.

### **3. Methodology**

#### **v. Study Period**

We choose to review the period inclusive of the dates August 15 to December 15, 2012. Initial observations show that the decrease in dark trading is abrupt, and aligned with the date of the dark rule amendments, so we expect that any other impacts resulting from the dark rule amendments will also be



evident in a narrow interval<sup>6</sup>. Our review period, which covers a two-month window prior to and following the dark rule amendments, is the same period used by Foley and Putniņš (Foley and Putniņš 2015). This provides the benefit of making our results comparable to their work.

The pre period is from August 15 to October 14, 2012 inclusive. The post period is from October 15 to December 15, 2012 inclusive. This period includes the US Thanksgiving holiday and two days when US markets were closed due to Hurricane Sandy. These outlier dates are removed when computing liquidity or market quality measures, as the absence of US trading flow impacts the quality of the Canadian equity marketplace.

## **vi. Data**

All of the Canadian equity marketplaces provide trading data in a standardized form, the Financial Information eXchange (FIX) format, to IIROC via a real-time regulatory feed. This data includes all trade, order and quote messages, including same-date trade cancellation and correction messages, and contains both publicly available fields and confidential regulatory markers. The regulatory data is used by IIROC's real-time surveillance system and is also stored in the Equity Data Warehouse (EDW) database for post-trade surveillance and analysis.

During the time period of our study, all Canadian equity marketplaces (see [Table 1](#)) were providing trading data to IIROC. IIROC is therefore able to rely on a rich cross-market dataset for the purposes of conducting this study.

## **vii. Security Groups**

We review the impact of the dark rule amendments on two subsets of securities. The first subset includes 241 securities which are constituents of the S&P/TSX Composite Index<sup>7</sup> ("TSX Comp") during the study period. The second subset includes 44 highly-liquid ETFs<sup>8</sup> ("HL ETF"). Preliminary investigation of dark trading shows us that these two subsets of securities account for 94% of all dark trading (75% of all lit trading) prior to the dark rule amendments, and 93% (78% in the lit) afterward. The security subsets therefore represent securities which are both heavily traded in the dark (and therefore likely to have been most impacted by the dark rule amendments) and support conclusions that are relevant and widely applicable in the context of Canadian equity trading.

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<sup>6</sup> Changes to short sale rules also took effect on October 15<sup>th</sup> 2012 in tandem with the dark rule amendments. While the study focuses on changes resulting from the dark rule amendments, it is possible that some effects we observe are confounded by the short sale rule changes. We note that interlisted securities were not impacted by the short sale rule changes as they were already exempt from the tick rule. The recent study by Comerton-Forde, Malinova and Park, which used a masked IIROC dataset, chose to review trading in interlisted securities in order to remove potential short sale rule confounding effects (2015).

<sup>7</sup> We exclude securities which were not part of the TSX Composite Index throughout the entire study period, and then remove one security which traded at a price below \$1, and FFH, which traded above \$300 per share for the entire period. The next highest priced security was AGU at just above \$100.

<sup>8</sup> We include securities which were identified by the TSX reference data as ETFs, and which were included in the IIROC highly-liquid security list on every day of our study period.



## viii. Trader Segments

Dividing the trading activity observed on the Canadian equity markets into different trader segments help us assess the costs and benefits experienced by some of the major stakeholders. For the purpose of this report, we identify four broad trader segments.

1. Retail (RET)
  - Includes trading by retail clients and employees of brokers
2. Buyside Client (Buyside)
  - Includes large institutional clients
3. High Frequency Trading (HFT)
  - Includes electronic liquidity providers
  - Includes high frequency broker strategies
4. Specialist and Sell Side Strategy (Sellside)
  - Includes specialist market-making activity
  - Includes client facilitation and low-frequency broker strategies

The trader segments expand upon the results of IIROC's paper "Identifying Trading Groups – Methodology and Results" (IIROC 2014)<sup>9</sup>. We use the UserID classification results established for March 2013.

We choose to report on a subset of UserIDs that existed prior to the study period and which are classified in March 2013, to avoid sample selection bias – otherwise more UserIDs would be included in the sample as the dates approached March 2013 when the UserIDs are classified. Our sample includes 94% of trading value in the TSX Comp and 93% of trading value in the HL ETF in the study period.

### A Note on EntityID

As part of the investigation into market-met internalization, we review the top active and passive users of dark liquidity. In order to make this comparison more useful, we choose to gather together all direct market access (DMA) UserIDs used by a single entity together under one Entity ID<sup>10</sup>. Only DMA clients are combined this way – broker UserIDs are not aggregated.

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<sup>9</sup> To make the classifications more useful for this study, we modify the original segments. First, we combine the sellside and buyside group (SB) with the specialist group (ST). Second, we divide the trades by these combined UserIDs into those marked client to identify the Buyside transactions and those marked non-client to identify the Sellside transactions. Using this process, we identify the trading activity attributable to each group, including situations where one UserID is used to conduct an intentional cross between a Buyside institution and a Sellside trader.

<sup>10</sup> During the period of our study, in connection with Exchange DMA requirements, brokers periodically provided IIROC with lists of DMA clients. These lists included the name of the DMA client and the UserID(s) assigned to it. UMIR 7.13, which established IIROC's reporting requirements associated with Direct Electronic Access clients, was implemented after the study period.



## ix. Analytic Methods

### Pre/Post Analysis

In a pre/post analysis, we compare the data points (consisting of a particular measurement for each stock day) in the pre period to the data points in the post period. We provide descriptive statistics in both periods and in addition perform a t-test to establish if significant change is observed. We follow standard notation in showing strong significance at the 1% level (\*\*\*) , moderate significance at the 5% level (\*\* ) and weak significance at the 10% level (\*). For the purpose of this paper we only consider results where we have established significance at the 5% or 1% level. However, this simple pre/post analysis does not provide evidence of causality.

### Two-stage Regression and Controlling for Other Factors

We conduct a two-stage least squares regression which has the dual benefit of establishing the dark rule as a probable cause for any observed changes, and controlling for other factors. This method is discussed by Foley and Putniņš (2015). In the first stage, a prediction of the level of dark trading activity is generated. In the second stage, the estimated level of dark trading is used to explain the observed level of a market quality metric. We have used this two-stage regression to explain TWAS, VWES, VWRS, market depth, volatility and mid-quote return autocorrelation. The control variables we use are as follows:

- Time: A variable to control for the trend over the study period: the series takes the value 0 on the first day in the sample and is increased by 1 every subsequent day
- Natural logarithm of dollar volume: Value of overall trading for each stock date combination
- Volatility: High minus low quoted price, divided by the time-weighted average mid-quote for each stock date combination (this control variable is excluded from the regression of measures of price efficiency)
- Price: Time-weighted average mid-quote for each stock date combination

In the first stage regression, we estimate the relationship between dark trading value and the dark rule amendments, using selected control variables (time, value, volatility and price):

$$Dark_{it} = \alpha_i + \beta D_t^{Post} + \sum_{j=1}^4 \gamma_j Control_{j,it} + \varepsilon_{it}$$

$Dark_{it}$  is the percentage of dark value relative to the total value of trading for each stock  $i$  on each date  $t$ .  $\alpha_i$  is a set of stock fixed effects.  $D_t^{Post}$  is a dummy variable which takes the value 0 for the pre period and 1 for the post period.

In the second stage regression, we estimate the relationship between the dependent variables TWAS, VWES, VWRS, market depth, volatility and mid-quote return autocorrelation and the estimated level of dark trading from the first regression, using the same set of selected control variables, as follows:



$$y_{it} = \alpha_i + \beta \widehat{Dark}_{it} + \sum_{j=1}^4 \gamma_j Control_{j,it} + \varepsilon_{it}$$

$y_{it}$  is the market quality metric of interest for each stock  $i$  on each date  $t$ .  $\widehat{Dark}_{it}$  is the fitted level of dark trading.

## x. Measuring Trading Activity

We report aggregate trading activity measured by value (dollar volume) for the study period. We report on the following measurements for the TSX Comp and the HL ETF security subsets:

- Dark value as a percentage of total value
- Dark trade size
- Lit trade size
- Dark daily value
- Lit daily value
- Total daily value

In Canada, all trades are publically disseminated. Only certain types of orders can be withheld from dissemination. For the purpose of this report we categorize trades as dark when one or both orders composing the trade are dark.

Refer to Appendix A: Data Specifications for further details concerning the specific data used when measuring trading activity.

## xi. Measuring Market Quality

For details concerning the specific data used in the calculations of the following market quality measures, see Appendix A: Data Specifications. This Appendix outlines the date range, time frame, security subset, types of trading messages and marketplaces which are included in the measurement of the market quality metrics. It also describes the removal of outlier data, when relevant. The following categories of outliers are noted: date, observations during a locked or crossed market state, and outlier levels of negative effective spreads<sup>11</sup>.

For the purpose of this paper we focus on evaluating changes to overall market quality. We explore changes to the following measures of liquidity (spreads, market depth and trading costs) and price efficiency (volatility and mid-quote return autocorrelations). A pre/post analysis and a two-stage least squares regression analysis is conducted on all measures of liquidity and price efficiency. We also

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<sup>11</sup> Negative effective spreads occur on the active side of the trade when: there are data issues regarding calculation of the NBBO; certain order types allow an order to change price and trade immediately while maintaining their passive status; latency at a marketplace allows trades to take place at an NBBO which is no longer current; and when markets are locked or crossed. We address this issue by removing net negative active effective spreads aggregated by security, UserID, traded market, account type and dark or lit at the 1% level. We note that analysts who use datasets which lack the information concerning who is the active initiator of the trade, and who use algorithms to determine the active side, would have no means of observing negative effective spreads.



explore an element of competition (the inverse Herfindahl index) which can influence market quality using a pre/post analysis.

### **Time-Weighted Average Spread**

We calculate the TWAS for each stock-day combination. The national best bid and offer (NBBO)<sup>12</sup> in effect at the time of every quote event from each marketplace is used in the calculation. Time periods where the quote is locked (NBBO spread is zero) or crossed (NBBO spread is negative) are not included in the TWAS calculation.

### **Effective and Realized Spread**

In this study, volume-weighted average effective spreads (VWES) and volume-weighted realized spreads (VWRS) are aggregated for each stock date. Effective spreads reflect the transaction cost while the realized spreads reflect the price movement from the trade price to the post-trade value (Bessembinder and Venkataraman 2010). We calculate the effective spreads for each stock date combination as follows:

$$ES_{it} = 2D_{it} \times \frac{(P_{it} - V_{it})}{V_{it}}$$

Here,  $D_{it}$  is a dummy variable which takes the value +1 for the buy side of the trade and -1 for the sell side of the trade.  $P_{it}$  is the trade price.  $V_{it}$  is the current value of the security, proxied by the mid-point price at the time of the trade.

Similarly, realized spreads are calculated for each stock date combination as follows:

$$RS_{it} = 2D_{it} \times \frac{(P_{it} - V_{it+5})}{V_{it}}$$

Here, we define  $V_{it+5}$  as the future value of the security, proxied by the mid-point price 5 minutes after the trade. The proxies we use for  $V_{it}$  and  $V_{it+5}$  are the same proxies mandated by the SEC for the purpose of comparing market centers (Preece and Rosov 2014; SEC 2013).

Note that we calculate the effective and realized spreads for both the buy and sell side of each trade.

For the pre/post analysis and regression, we report the VWES and VWRS for the active side of the trade<sup>13</sup>. Additionally, when we report the aggregate results by trader segment, we specify active, passive and all. The net effective spread for any trade where the same trader segment is on both sides of the trade is zero, with the result that the “all” effective spread for a trader segment also incorporates information about the volume which is transacted passively vs. actively.

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<sup>12</sup> Calculated by IIROC using individual marketplace quotes and stored in the IIROC data.

<sup>13</sup> The IIROC data contains a marker indicating if the trader was active or passive.



Trades which take place when the quote is locked or crossed are not included in the VWES or VWRS measures. Additionally, trades which do not have both an active and passive side are excluded from the analysis: cross trades are a common example of a trade of this type.

### Trading Costs by Trader Segment

VWES, VWRS and volumes are broken out by trader segment and used to observe if trading costs and benefits increased or decreased. For particular trader segments of interest, a two-stage least squares regression is conducted.

### Market Depth

Market depth is a measurement of the passive order volume available in the book. The volume available at a number of price levels relative to the NBBO is time weighted over the course of the day. Both dark and lit orders are included.

Time-weighted order volumes for each of the following price levels are calculated for each stock date:

Table 3: Price Levels for Market Depth relative to NBB and NBO

Price Level	Bid	Ask
Level 0	>NBB	<NBO
NBB NBO	NBB	NBO
Level 2	NBB - 1 trading increment	NBO + 1 trading increment
Level 3	NBB - 2 trading increments	NBO + 2 trading increments
Level 4	NBB - 3 trading increments	NBO + 3 trading increments
Level 5	NBB - 4 trading increments	NBO + 4 trading increments

By definition, price level 0 is made up entirely of order volume in the dark. The converse is not true, however, and the order volume at the NBBO and deeper could contain dark limit orders.

A pre/post analysis and a two-stage least squares regression is conducted of the log time-weighted order volume in the lit, dark, and overall (lit plus dark).

### Volatility

Volatility is a measurement of the deviations of price relative to their equilibrium values. For this paper, we compute volatility using the standard deviation of the compound mid-quote returns (Foley and Putniņš 2015). The compound return is calculated as:

$$r_{\tau} = \ln\left(\frac{P_{\tau}}{P_{\tau-1}}\right)$$

Here,  $P_{\tau}$  is the  $\tau$ -th element in the sequence of mid-quotes sampled by a given intra-day frequency. A pre/post analysis is conducted of the mid-quote returns at 1 minute, 5 minute and 30 minute





frequencies. We then combine the volatilities at different frequencies by calculating their first principal component and conducting a two-stage least squares regression.

### **Mid-quote Return Autocorrelation**

Mid-quote return autocorrelations measure how much a sampled series of quotes exhibit short-term predictability. This measure shows how trading prices change over short time horizons; autocorrelations near zero indicate that the change in price is random and consistent with the efficient market hypothesis, whereas autocorrelations away from zero indicate that prices are more predictable (either trending predictably or exhibiting predictable reversion to the mean). Taking the absolute value of the autocorrelation yields an informational inefficiency measure: zero being highly efficient and one being highly inefficient (Anderson, et al. 2013).

The informational inefficiency measure is computed as:

$$ac = |\text{Corr}(r_{\tau+1}, r_{\tau})|$$

A pre/post analysis is conducted of this metric at 10 second, 30 second, and 60 second sample frequencies. We then combine the return autocorrelations at different frequencies by calculating their first principal component and conducting a two-stage least squares regression.

### **Diversity of Liquidity Provision**

The inverse Herfindahl index (invHI) is used to determine the diversity or concentration of the value of liquidity provision by EntityID. The formula is as follows:

$$invHI = \frac{1}{\sum_i s_i^2 - 1} - 1$$

where  $s_i$  is the percentage traded dollar volume by market participant  $i$ .

The invHI has been interpreted as the number of effective competitors (Bowen and Wiersema 2005); we are using it to measure the concentration of liquidity provision in the market. An increase in the invHI implies more diversity of liquidity provision. A decrease in the invHI implies a smaller number of liquidity providers are sharing the provision of liquidity.

Additionally, we review the liquidity provisioning by Entity ID, ranked separately by overall and dark liquidity provisioning. We categorize the passive side of all trades between active and passive traders as the liquidity provisioning side of the trade.

## **xii. Measuring Market-Met Client Internalization (MMI)**

We report aggregate trading activity measured by value. MMI activity is identified by the following conditions:

- Both sides of the trade originate from the same broker



- One side of the trade is marked as client (CL) and the other side of the trade is marked as broker strategy (NC, IN, ST or OT)
- The trade is not an intentional cross

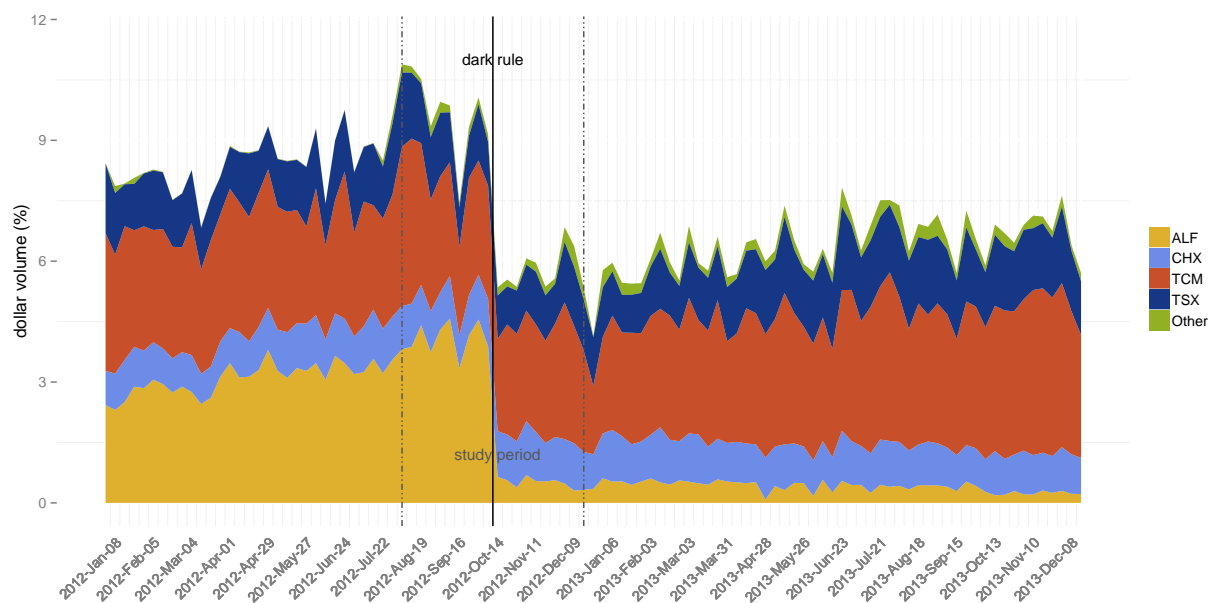
We review MMI in several ways. First, we measure the value of MMI conducted by broker and compare the daily mean for the pre and post periods. Second, we measure the value of MMI by Entity ID and report the top ranked client and principal traders (identities masked).

## 4. Findings

### xiii. Trading Activity Results

Figure 1 through Figure 3 show that there is an immediate and significant decrease in dark trading as a percentage of overall trading value in all Canadian listed securities after the implementation of the dark rule amendments. Following the initial decrease in dark trading concurrent with the dark rule amendments, the percentage of dark trading exhibits an increasing trend<sup>14</sup>. Figure 1 shows that dark trading on IntraSpread has the most significant decrease, and unlike the other venues offering dark order execution, continues a downward trend in the months after the rule amendments. Table 7 confirms this trend for the study period. In Figure 2, as noted earlier, the impact of the rule change is largely captured in the TSX Composite and ETF security segments. Figure 3 shows that the HFT and retail segments experience the largest drop in volume of dark trading from the pre period to the post period. We also see that in the post period, dark trading by the buy-side exhibits a long term increase. Table 5 and Table 6 show that within our study period, the HFT and retail segments drop significantly in the TSX Comp and that all trader segments drop significantly in the HL ETF.

Figure 1: Percentage of Dark Trading Value by Traded Market



<sup>14</sup> A long term trend (outside the study period window) is shown here. However, all impact analysis is done in the study window of approximately 4 months.



Figure 2: Percentage of Dark Trading Value by Security Type

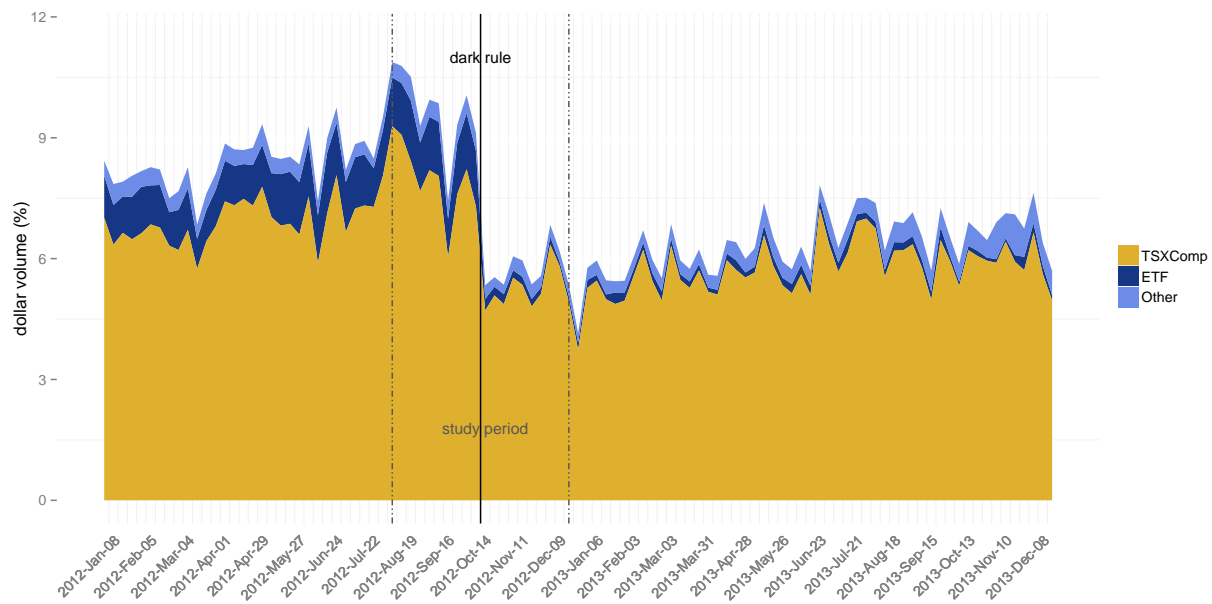
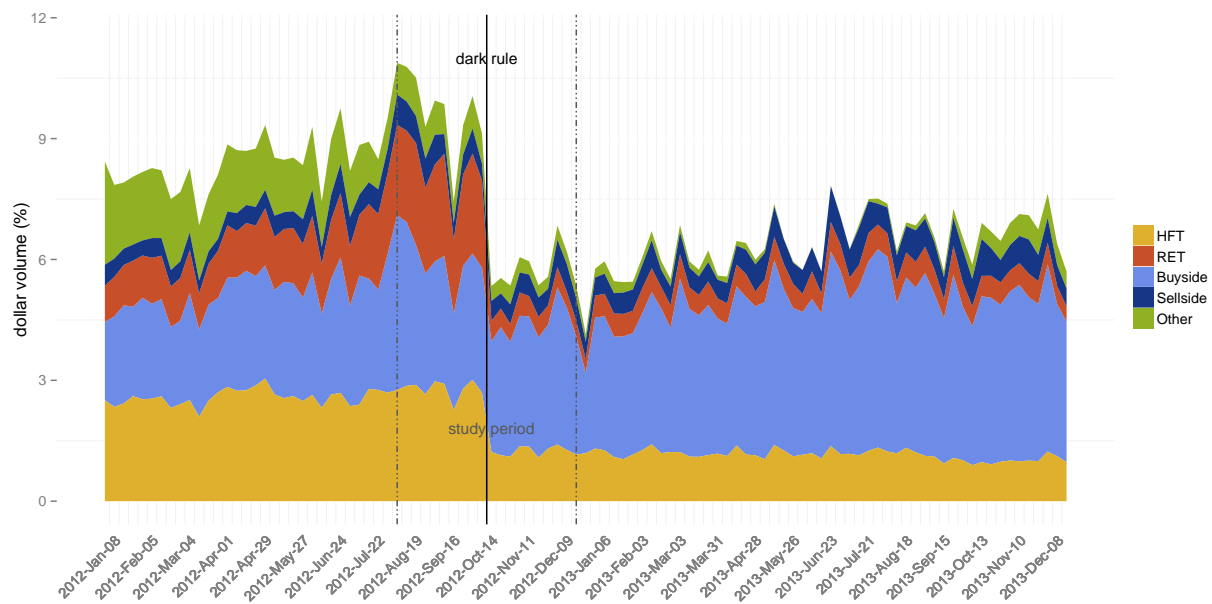


Figure 3: Percentage of Dark Trading Value by Trader Segment



We report daily average summary statistics (% dark trading, value of dark and lit trading, dark and lit trade size) in Table 4. We observe the following results:

- Average daily dark trading value decreases significantly in the TSX Comp (as expected). Average daily lit trading value increased, but not at significance (the daily increase is a small portion of



the total lit and therefore the increase is less significant). Overall (dark plus lit) average daily trading value showed no change.

- Average daily dark trading value decreases significantly in the HL ETF and the average daily lit trading value increases significantly, while average daily overall (dark plus lit) trading value showed no change. We also observe a decrease in the daily average dark trade size (measured by value).

#### **xiv. Market Quality Results**

In the following section we evaluate changes to overall market quality. We explore changes to the following measures of liquidity (spreads, market depth and trading costs) and price efficiency (volatility and mid-quote return autocorrelations).

##### **Spread Measures**

We review TWAS, VWES and VWRS from three perspectives.

First, we measure the differences between the pre and post periods. These results are outlined in Table 8. This includes the robustness tests in which we calculate the spread metrics, first, as relative spreads measured in basis points (bps) and second, actual spreads measured in cents. These results show either weak or no significant differences.

Second, we perform a two-stage regression analysis and we report the results of this analysis in Table 9 and Table 10.

Table 9 reports the results from the first stage of the two-stage least squares regression. It indicates that the rule change is associated with a decrease in the average percentage of dark trading at statistically significant levels for both the TSX Comp and the HL ETF. Table 10 reports second-stage estimates of the impact of dark trading on liquidity metrics and show no statistically significant results on either the TSX Comp or the HL ETF.

Finally, we break down our results in Table 11 by trading segments as described in Section viii. Here we see deterioration in effective spreads for certain trader segments. In particular we see that active retail transactions, which constitute 67% of total (active and passive) retail trading, incur a higher transactional cost in the post period as measured by effective spreads. This is offset by the benefits incurred by passive retail and overall we do not see any significant changes in the retail group. We also see the passive liquidity providers such as HFT benefit in earning higher effective spreads in the TSX Comp.

Table 12 through Table 15 shows the results of a two-stage least squares regression model for active retail and passive HFT. The results confirm the deterioration in market quality as measured by effective spread observed in the pre/post analysis.



Our results indicate that overall, market quality, as measured by spreads, is not impacted by the dark rule amendments. However, certain groups such as active retail and passive liquidity providers experienced significant changes to transaction costs.

### **Market Depth**

We report a pre/post analysis of volume-weighted market depth in one trading increment levels in Table 16 and Table 20 and the results of a regression analysis between Table 17 and Table 23.

In the TSX Comp and the HL ETF, lit market depth at the NBBO shows statistically significant increases in posted volume between the pre and post periods in both the pre/post analysis and the regression. Depth at Level 2 for the HL ETF also increases.

In the TSX Comp and the HL ETF, all levels of dark market depth show statistically significant decreases in posted volume between the pre and post periods in both the pre/post analysis and the regression. This result is expected. In the pre period, an entity can place market or limit orders in the dark which interact with incoming SDL or Marketflow orders, and trade at 10% or 20% of the NBBO, thus potentially allowing a market-making strategy to earn some fraction of the spread. Following the dark rule amendments, the economics of market-making strategies in the dark are potentially less profitable, as 50% price improvement narrows the effective spread to zero. We hypothesize that in the post period, market-making strategies largely withdraw from provisioning liquidity in the dark.

With regards to overall (dark plus lit) order volume at the NBBO and deeper (an important measure of overall liquidity in the Canadian equity market) we see no significant changes in market depth for either the TSX Comp or the HL ETF. In the case of the HL ETF, while we see significant increases in overall market depth in the pre/post analysis at most depths, these are not replicated when applying a regression model that controls for confounding factors.

We conclude that the dark rule amendments shifted market depth from dark to lit, but did not impact overall market depth at the NBBO or deeper for either the TSX Comp or the HL ETF.

### **Volatility and Return Autocorrelation**

We report volatility measured at different sample frequencies in Table 24 and Table 26. We find no statistically significant results from the regression analysis.

We report the return autocorrelation at various frequencies in Table 25. Return autocorrelation at 10 second, 30 second and 60 second sampling frequencies for TSX Composite securities show reduced informational efficiencies (away from stochastic random walk). The results at all frequencies are statistically significant and validated in the results of the regression model in Table 26. In case of the HL ETF, we find no statistically significant results as seen in Table 26.

### **Diversity of Liquidity Provision**

So far we have focused on market-wide impacts as measured by liquidity and efficiency. In this section we narrow down our view to observe the behaviours of individual liquidity providers which may provide



context for the market-wide impacts we observe. Reviewing liquidity provision is important in understanding the impact of the dark rule amendments because, as demonstrated by Comerton-Forde, Malinova and Park, the decrease in dark trading is the result of an absence of liquidity-providing orders in the dark as opposed to an absence of active liquidity seeking orders.

Table 27 reports the change in the overall concentration of liquidity provisioning (measured by invHI) for overall, lit, dark and for individual dark marketplaces. We find that liquidity provision in the TSX Comp is less competitive (more concentrated) in the lit and overall in the post period. In contrast, liquidity provision in the HL ETF did not change in the lit or overall in the post period.

When we drill down to liquidity provision by entity (Figure 4, Figure 5, Figure 7 and Figure 8) we can observe the behaviors of individual Entity IDs which result in the changes in concentration of liquidity provision. Additionally, we find three patterns of interest.

First, the largest overall liquidity providers are diversified across lit and dark markets in the pre period. In the post period, most of them decrease their liquidity provisioning in the dark, and increase their provisioning in the lit. This pattern is seen in both the TSX Comp and the HL ETF. This visual representation helps to interpret the results of the invHI for the TSX Comp, which shows more concentration in lit liquidity provision in the post period.

Second, a notable exception is the topmost liquidity provider of dark liquidity in the TSX Comp, which we label User 08. Liquidity provision by User 08 is highlighted in the figures and we observe that User 08's liquidity provisioning is almost entirely in the dark in the pre period, and following the dark rule amendment, it largely ceases to provide liquidity in either the dark or the lit. This pattern is seen in both the TSX Comp and the HL ETF.

Third, as noted before, dark trading in the HL ETF fell much more dramatically than dark trading in the TSX Comp, and this pattern can be observed on an Entity ID level in Figure 8 (see Appendix C: Figures). We can see one notable exception, the seventh-ranked dark liquidity provider (labeled User 34), which continued to provide significant liquidity in the HL ETF in the dark in the post period. By maintaining its dark liquidity provision, User 34 becomes the first ranked Entity ID in the post period. Our observation of the invHI for the HL ETF supports this observation – we observe significantly more concentration in dark liquidity provision in the post period.

Observing individual Entity IDs provides insight into how the rules impact individual trading strategies – and illustrates that the rules did not have a universal impact on all participants in the Canadian markets. Changes by individual strategies (either with or contrary in direction to changes by the majority) are sometimes large enough or significant enough to influence macro-level measures of market quality.



Figure 4: Top 20 LPs Ranked by Overall Liquidity Provision in TSX Comp

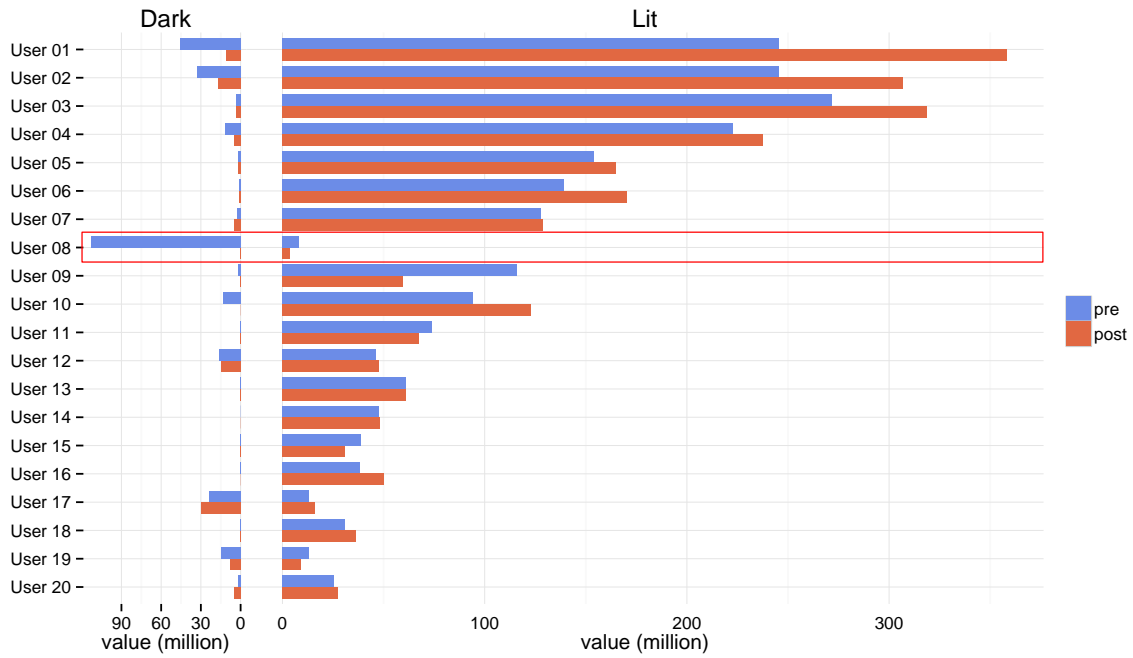
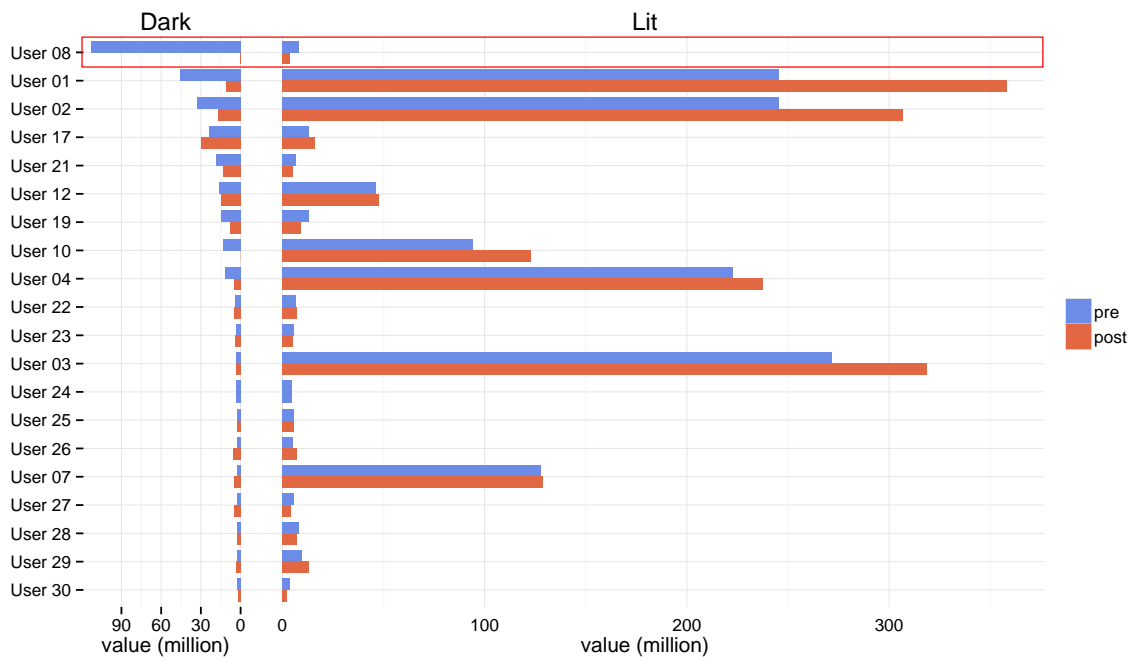


Figure 5: Top 20 LPs Ranked by Dark Liquidity Provision in TSX Comp





## xv. Market-Met Internalization (MMI)

In this final section of the report, we observe levels of MMI to determine the impact of the dark rule amendments. We report the daily average amount of MMI by value and as a percentage of each Broker's trading in Table 29. Overall (dark plus lit) levels of MMI in the TSX Comp decrease from 2.75% of all traded value in the pre period to 1.81% in the post period. This change is statistically significant. Overall (dark plus lit) levels of MMI in the HL ETF show a small and statistically insignificant increase.

Table 31 shows that 8.2% of all retail transactions in the TSX Comp are internalized in the market in the pre period and this percentage drops to 2.9% in the post period with a high level of statistical significance. In contrast, the level of retail internalization in the HL ETF does not change significantly.

One broker (labeled as Broker A) stands out as being involved in the largest volume of overall (dark plus lit) MMI in the pre period in both the TSX Comp and the HL ETF. Broker A also experiences the largest and most statistically significant drop in overall (dark plus lit) MMI in the TSX Comp and the HL ETF in the post period.

Figure 6: MMI for TSX Comp by Broker and Traded Marketplace

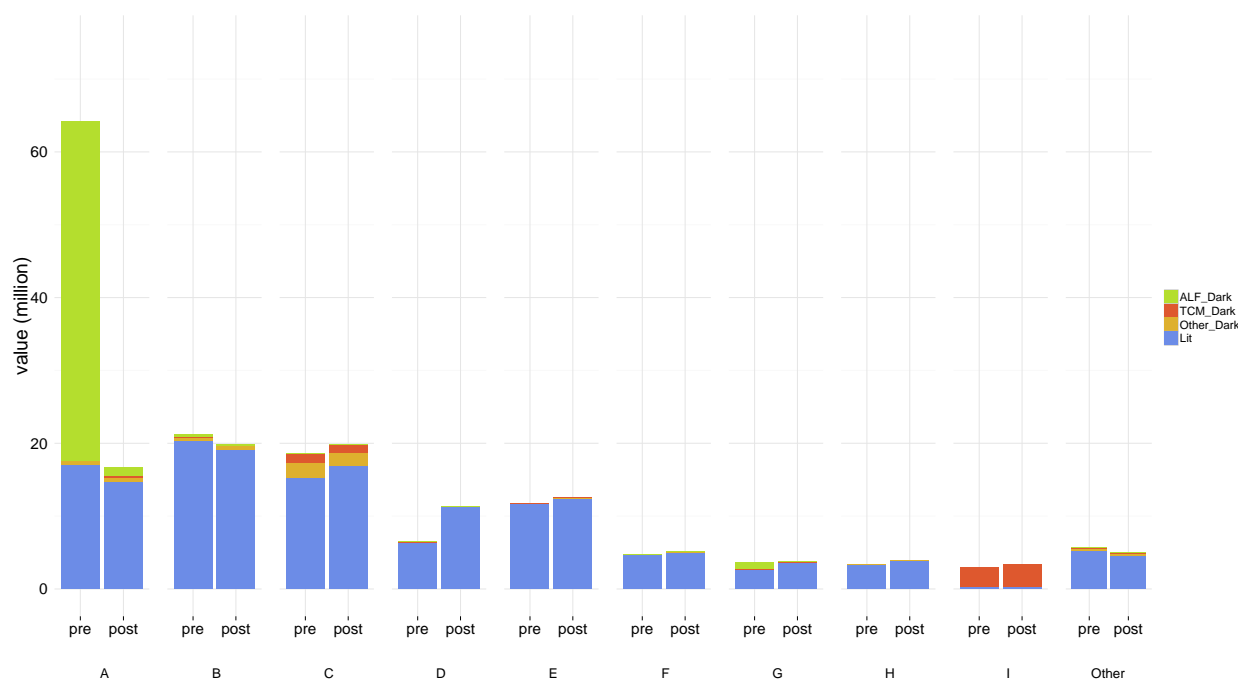


Figure 6 (Figure 9 for the HL ETF in Appendix C: Figures) illustrates the changes in MMI from the pre to the post period for each of the brokers involved in a significant amount of MMI, broken out by IntraSpread (ALF dark), TCM dark, other dark and lit. The majority of the MMI by Broker A in the pre period takes place in IntraSpread. No other brokers exhibit this pattern. Following the dark rule amendments, the amount and character of MMI by Broker A changes to resemble the pattern of MMI by other large brokers, with MMI concentrated in lit markets.





From Figure 9 (see Appendix C: Figures), we observe that the patterns exhibited by brokers in the HL ETF are more varied, with some brokers exhibiting more MMI and some brokers exhibiting less MMI after the dark rule amendments. The largest brokers involved in MMI show a consistent pattern of less MMI in the dark in the post period.

User 08, discussed above and shown to be the largest liquidity provider in the dark, is a UserID employing a strategy by Broker A. In Table 30 we report the top 5 UserIDs involved in MMI trading as either the principal or the client. We find that Broker A is represented disproportionately in the lists, both as principal and as client. This is most noticeable in the TSX Comp. It appears that Broker A took advantage of the existing marketplace structure to offer its clients 10% price improvement and to simultaneously benefit from making markets for its own and other's retail flow. No other broker exhibits this pattern of trading in the TSX Comp.

These results show that top dark liquidity providers are impacted differently by the dark rule changes. Those with business models dependent on availability of segregated retail flows are impacted more than those with more diversified liquidity provisioning activities. Such micro level impacts could be the drivers of the broader market quality impacts we observe – in particular the flow of benefits in transaction cost from active retail to dominant lit market liquidity providers.

## **5. Conclusion**

In summary, based on our analysis of the impact of the dark rule amendments, we conclude:

1. Dark trading activity is significantly reduced. Individual dark trading venues are impacted differently based on the role that dark played in their service offerings. Trading on IntraSpread, on which two-sided market-making strategies use dark trading to interact with a segregated flow of retail orders, is most strongly impacted when the dark rule amendments reduce such market-making opportunities. In contrast, trading on TCM, which has a more traditional dark participant group, trading to minimize information leakage and market impact, is less impacted. In line with these observations, of the trader segments, active retail traders and passive HFT show the greatest reduction in dark trading.
2. Evidence of change to market quality is mixed. Most measures show no significant change, with the exception of return autocorrelation which shows deterioration in information efficiency.
3. Incidental to measures of overall market quality, we note the following impacts. We see a re-distribution of costs and benefits with the active retail segment incurring higher transaction costs (as measured by effective spreads) and increased benefits to passive HFT. However, the trader segments as a whole are not impacted. We also see an improvement in lit market depth at NBBO as most liquidity providers shifted from dark to lit markets.
4. MMI decreases significantly, largely due to the exit of a few brokers who had implemented market-making strategies on IntraSpread to trade with the segregated retail flow on that marketplace.



On balance we believe that the regulatory objectives of the dark rule amendments are accomplished. We see a reduction in dark volume in the absence of meaningful price improvement with minimal market-wide impacts as most measures of market quality showed no deterioration.



## 6. Appendix A: Data Specifications

The following table describes the specific data used in the calculation of the results illustrated by each figure:

Figure	Measure	Units	Date Range	Outlier Date Removal	Time Range	TSX Comp	HL ETF	All Securities	Messages	Locked or Crossed	Marketplaces Included	t Statistics
1	Ext Summary by Mkt	\$	Jan/12 to Dec/13	No	All day			all	T	included	All	-
2	Ext Summary by Sec Type	\$	Jan/12 to Dec/13	No	All day	Full	Full	all	T	included	All	-
3	Ext Summary by Users	\$	Jan/12 to Dec/13	No	All day			all	T	included	All	-
4, 5	Top LPs TSX Comp (ranked by overall and by dark \$vol)	\$	study period	Yes	9:35 to 15:55	subset			T	removed	All	-
7,8	Top LPs ETF (ranked by overall and by dark \$vol)	\$	study period	Yes	9:35 to 15:55		subset		T	removed	All	-
6	MMI by broker TSX Comp	\$	study period	Yes	all day	subset			T	removed	All	-
9	MMI by broker ETF	\$	study period	Yes	all day		subset		T	removed	All	-



The following table describes the specific data used in the calculation of the results reported in each table:

Table	Measure	Units	Date Range	Outlier Date Removal	Time Range	TSX Comp	HL ETF	All Securities	Messages	Locked or Crossed	Marketplaces Included	t Statistics <sup>15</sup>
4	Summary Statistics	\$	Study Period	No	All day	subset	subset	all	T + TCxl - Tcorr	included	All	double
5,6	Trader Segment Statistics	\$	Study Period	Yes	All day	subset	subset		T	removed	All	single
7	Market Segment Statistics	\$	Study Period	Yes	All day	subset	subset		T	removed	All	single
8	TWAS	bps	Study Period	Yes	9:35 to 15:55	subset	subset		Q	removed	All	double
8	VWES & VWRS	bps	Study Period	Yes	9:35 to 15:55	subset	subset		T	removed	All	double
9, 10, 12,13, 14, 15, 17, 18,19, 21,22, 23, 26	Regression models		Study Period	Yes	9:35 to 15:55	subset	subset		T	removed	All	double
	Regression Models	Control Var: log\$Vol	Study Period	Yes	9:35 to 15:55	subset	subset		T	removed	All	-
		Control Var: Volatility	Study Period	Yes	9:35 to 15:55	subset	subset		Q	-	All	-
		Control Var: Price (TWAMP)	\$	Study Period	Yes	9:35 to 15:55	subset	subset		T	removed	All
11	Spreads and Volume by Segment	bps volume	Study Period	Yes	9:35 to 15:55	subset	subset		T	removed	All	double
16, 20	Market Depth	volume	Study Period	Yes	9:30 to 16:00	subset	subset		O	included	All	double
24	Volatility		Study Period	Yes	9:35 to 15:55	subset	subset		Q	included	All	double
25	Autocorrelation		Study Period	Yes	9:35 to 15:55	subset	subset		T	included	All	double
27	Diversity: invHI		Study Period	Yes	9:35 to 15:55	subset	subset		T	removed	All	single
28	Top Liquidity Providers	\$	Study Period	Yes	9:35 to 15:55	subset	subset		T	removed	All	single
29	MMI by PO	\$	Study Period	Yes	all day	subset	subset		T	included	All	single
30	MMI by Entity	\$	Study Period	Yes	all day	subset	subset		T	included	All	single
31	MMI by Retail and non-Retail Clients	\$	Study Period	Yes	all day	subset	subset		T	included	All	single

<sup>15</sup> “Single” indicates that the t-test is performed over one dimensional data (daily observations of one measure). “Double” indicates that the t-test is performed over two dimensional data (daily observations for multiple securities). Standard errors are double clustered by stock and date (Thompson 2011).



## 7. Appendix B: Tables

Table 4: Descriptive Statistics

### Panel A: TSX Comp

	pre			post			difference	t statistic
	mean	median	standard deviation	mean	median	standard deviation		
Dark \$ volume / total \$ volume %	11.23	9.41	8.50	7.74	5.39	7.89	-3.50	(-10.892)***
Dark trade size (\$1000)	6.49	4.84	8.92	6.50	4.51	13.08	0.0128	(0.0794)
Lit trade size (\$1000)	5.60	4.23	7.20	5.69	4.24	7.25	0.0869	(0.4932)
Dark daily \$ volume (100m)	5.60	5.49	0.989	3.91	4.02	1.09	-1.69	(-7.53)***
Lit daily \$ volume (100m)	50.72	48.33	12.16	52.85	55.44	11.63	2.13	(0.828)
Total daily \$ volume (100m)	56.32	54.79	12.78	56.76	59.30	12.48	0.442	(0.162)

### Panel B: HL ETF

	pre			post			difference	t statistic
	mean	median	standard deviation	mean	median	standard deviation		
Dark \$ volume / total \$ volume %	16.66	15.21	10.86	2.97	2.24	2.90	-13.69	(-10.43)***
Dark trade size (\$1000)	10.95	10.15	5.59	8.94	7.51	7.63	-2.01	(-3.303)***
Lit trade size (\$1000)	11.95	9.21	10.45	12.84	10.18	11.43	0.891	(2.039)**
Dark daily \$ volume (100m)	0.917	0.896	0.198	0.144	0.137	0.0608	-0.773	(-23.92)***
Lit daily \$ volume (100m)	4.52	4.45	0.994	5.34	5.40	1.29	0.828	(3.35)***
Total daily \$ volume (100m)	5.43	5.38	1.16	5.49	5.56	1.31	0.0556	(0.209)

### Panel C: All Securities

	pre			post			difference	t statistic
	mean	median	standard deviation	mean	median	standard deviation		
Dark daily \$ volume (100m)	6.92	6.82	1.17	4.35	4.48	1.15	-2.57	(10.26)***
Lit daily \$ volume (100m)	66.80	63.61	20.29	69.89	72.41	14.91	3.09	(0.799)
Total daily \$ volume (100m)	73.71	70.39	20.91	74.23	76.91	15.80	0.523	(0.130)



Table 5: Descriptive Statistics by Trader Segment – TSX Comp

**Panel A: TSX Comp Value (\$100 m)**

Segment	Type	pre			post			difference	t statistic
		mean	median	standard deviation	mean	median	standard deviation		
RET	Dark	2.36	2.32	0.490	0.581	0.586	0.110	-1.78	(-22.72)***
	Lit	7.34	7.23	1.52	9.27	9.06	1.40	1.93	(6.00)***
	Total	9.70	9.60	1.97	9.85	9.65	1.43	0.149	(0.392)
Buyside	Dark	3.99	4.05	0.797	4.43	4.44	1.07	0.445	(2.15)**
	Lit	39.27	36.34	9.46	43.50	41.07	12.10	4.23	(1.775)*
	Total	43.26	40.48	9.86	47.93	44.73	12.42	4.67	(1.900)*
Sellside	Dark	0.700	0.665	0.201	0.686	0.642	0.261	-0.0137	(-0.266)
	Lit	13.04	13.42	2.71	13.84	13.73	3.46	0.800	(1.174)
	Total	13.74	13.94	2.76	14.53	14.78	3.59	0.787	(1.121)
HFT	Dark	3.15	3.10	0.566	1.67	1.70	0.325	-1.48	(-14.56)***
	Lit	25.61	25.32	5.36	27.02	27.61	4.24	1.41	(1.325)
	Total	28.76	28.44	5.84	28.69	29.07	4.49	-0.0725	(-0.0633)

**Panel B: TSX Comp Active Retail and Passive HFT Value (\$100 m)**

Segment	Type	Pre	Post	difference	t statistic
Active RET	Dark	2.35	0.577	-1.77	(-22.733)***
	Lit	4.12	6.01	1.89	(10.687)***
	Total	6.47	6.58	0.111	(0.480)
Passive HFT	Dark	2.35	0.561	-1.79	(-25.706)***
	Lit	17.20	19.26	2.05	(3.052)***
	Total	19.55	19.82	0.267	(0.368)



Table 6: Descriptive Statistics by Trader Segment – HL ETF

**Panel A: HL ETF Value (\$1 m)**

Segment	Type	pre			post			difference	t statistic
		mean	median	standard deviation	mean	median	standard deviation		
RET	Dark	71.15	71.04	15.40	7.17	6.44	2.96	-63.98	(-26.134)***
	Lit	132.38	129.05	24.20	193.73	192.20	33.92	61.35	(9.503)***
	Total	203.53	202.43	37.58	200.90	202.16	35.22	-2.63	(-0.329)
Buyside	Dark	11.02	9.37	5.58	3.71	2.52	4.20	-7.30	(-6.723)***
	Lit	118.68	108.19	43.05	133.27	123.73	40.83	14.59	(1.583)
	Total	129.70	122.91	44.88	136.98	129.72	41.20	7.28	(0.770)
Sellside	Dark	2.11	1.41	1.98	0.847	0.309	1.23	-1.26	(-3.473)***
	Lit	79.67	66.92	41.08	77.49	73.66	35.99	-2.18	(-0.257)
	Total	81.78	68.51	42.07	78.34	73.85	36.04	-3.44	(-0.400)
HFT	Dark	72.91	72.48	16.79	12.85	11.99	4.31	-60.06	(-22.200)***
	Lit	389.09	385.06	92.39	474.29	457.21	117.18	85.20	(3.683)***
	Total	462.00	463.90	106.23	487.15	469.56	119.20	25.14	(1.015)

**Panel B: HL ETF Active Retail and Passive HFT Value (\$1 m)**

Segment	Type	Pre	Post	difference	t statistic
Active RET	Dark	70.91	5.73	-65.18	(-12.313)***
	Lit	73.35	135.02	61.67	(15.47)***
	Total	144.43	142.18	-2.25	(-0.413)
Passive HFT	Dark	67.58	8.05	-59.52	(-24.84)***
	Lit	228.66	294.58	65.92	(4.986)***
	Total	296.23	302.63	6.40	(0.439)



Table 7: Descriptive Statistics – Dark Trading by Marketplace

**Panel A: TSX Comp (\$1m)**

	pre			post			difference	t statistic
	mean	median	standard deviation	mean	median	standard deviation		
ALF	420.8	419.9	91.8	62.2	62.9	19.8	-358.5	(-24.46)***
TCM	348.1	338.5	79.3	380.0	381.3	89.7	31.8	(1.71)*
TSE	154.3	150.4	36.6	150.7	143.8	44.1	-3.61	(-0.406)
CHX	124.3	120.1	25.2	151.7	148.3	30.8	27.4	(4.44)

**Panel B: HL ETF (\$1m)**

	pre			post			difference	t statistic
	mean	median	standard deviation	mean	median	standard deviation		
ALF	137.0	136.9	30.1	13.6	12.8	5.91	-123.4	(-25.75)***
TCM	27.0	24.5	10.1	4.79	1.85	7.11	-22.23	(-11.60)***
TSE	1.99	1.41	1.63	1.97	1.13	2.37	-0.0216	(-0.0486)
CHX	6.83	6.18	2.91	7.53	6.86	3.08	0.708	(1.077)





Table 8: Spread Measures

<b>Panel A: TSX Comp (bps)</b>			
	<b>pre</b>	<b>post</b>	<b>t statistic</b>
TWAS	12.43	12.62	(1.3493)
VWES (active)	11.09	11.47	(1.9506)*
VWRS (active)	-2.18	-1.84	(1.8964)*

<b>Panel B: TSX Comp (cents)</b>			
	<b>pre</b>	<b>post</b>	<b>t statistic</b>
TWAS	2.370	2.378	(0.2319)
VWES (active)	1.968	2.048	(0.9177)
VWRS (active)	-0.2908	-0.2712	(0.5949)

<b>Panel C: HL ETF (bps)</b>			
	<b>pre</b>	<b>post</b>	<b>t statistic</b>
TWAS	9.29	9.21	(-0.3542)
VWES (active)	8.71	9.02	(1.193)
VWRS (active)	1.62	1.84	(0.8464)

<b>Panel D: HL ETF (cents)</b>			
	<b>pre</b>	<b>post</b>	<b>t statistic</b>
TWAS	1.215	1.216	(0.0181)
VWES (active)	1.143	1.177	(2.331)**
VWRS (active)	0.2775	0.3231	(1.548)



Table 9: First Stage Regression - Level of Dark Trading

<b>Panel A: TSX Comp</b>		
<b>Variable</b>	<b>\$ Dark / \$ Total</b>	<b>t statistic</b>
Intercept	0.168	(5.212)***
Dark Rule	-0.0396	(-7.334)***
Time	$8.26 \times 10^{-5}$	(0.809)
log(\$Volume)	$-5.05 \times 10^{-3}$	(-2.107)**
Volatility	$-2.83 \times 10^{-5}$	(-3.851)***
Price	$7.60 \times 10^{-5}$	(0.0829)
Observations	19757	
Adjusted R <sup>2</sup>	0.1544	
Fixed Effects	Stock	

<b>Panel B: HL ETF</b>		
<b>Variable</b>	<b>\$ Dark / \$ Total</b>	<b>t statistic</b>
Intercept	0.254	(6.37)***
Dark Rule	-0.0782	(-10.848)***
Time	$1.03 \times 10^{-4}$	(1.459)
log(\$Volume)	$-1.287 \times 10^{-2}$	(-4.689)***
Volatility	$2.09 \times 10^{-5}$	(2.705)***
Price	$6.12 \times 10^{-4}$	(1.809)*
Observations	3603	
Adjusted R <sup>2</sup>	0.6318	
Fixed Effects	Stock	



Table 10: Second Stage Regression – Spread Measurements

<b>Panel A: TSX Comp</b>						
Variable	TWAS		VWES		VWRS	
	coefficient	t statistic	coefficient	t statistic	coefficient	t statistic
Intercept	54.21	(22.75)***	56.13	(5.052)***	2.41	(0.5994)
$\widehat{Dark}$	-10.44	(-1.908)*	-4.74	(-0.928)	$-2.38 \times 10^{-3}$	(-0.003)
Time	$-3.43 \times 10^{-3}$	(-0.843)	$6.24 \times 10^{-3}$	(1.108)	$7.86 \times 10^{-3}$	(1.579)
log(\$Volume)	-1.852	(-11.49)***	-2.40	(-2.235)**	0.0665	(0.232)
Volatility	$7.28 \times 10^{-3}$	(10.24)***	0.0234	(1.607)	-0.0204	(-7.963)***
Price	-0.0976	(-1.474)	-0.0111	(-0.106)	-0.0351	(-0.984)
Observations	19757		19757		19757	
Adjusted R <sup>2</sup>	0.9276		0.4215		0.2015	
Fixed Effects	Stock		Stock		Stock	

<b>Panel B: HL ETF</b>						
Variable	TWAS		VWES		VWRS	
	coefficient	t statistic	coefficient	t statistic	coefficient	t statistic
Intercept	19.49	(10.07)***	18.84	(8.016)***	22.56	(4.603)***
$\widehat{Dark}$	1.65	(0.676)	-2.06	(-0.857)	-4.88	(-0.6851)
Time	$5.30 \times 10^{-3}$	(1.124)	$8.30 \times 10^{-3}$	(1.944)*	$-2.56 \times 10^{-3}$	(-0.2423)
log(\$Volume)	-0.299	(-2.786)***	-0.221	(-1.933)*	-0.829	(-2.585)***
Volatility	$5.20 \times 10^{-4}$	(1.148)	$9.63 \times 10^{-4}$	(1.652)*	$-7.575 \times 10^{-3}$	(-3.415)***
Price	-0.505	(-7.536)***	-0.536	(-7.380)***	-0.314	(-4.947)***
Observations	3603		3603		3603	
Adjusted R <sup>2</sup>	0.9396		0.9235		0.1564	
Fixed Effects	stock		stock		stock	



Table 11: Trading Costs and Volume by Trader Segment

**Panel A: TSX Comp**

Segment	Side	VWES (bps)			VWRS (bps)			Volume (1000)		
		pre	post	t statistic	pre	post	t statistic	pre	post	t statistic
RET	active	12.21	12.78	(2.951)***	3.37	4.42	(3.903)***	132.2	144.2	(1.1481)
	passive	-12.04	-12.49	(-3.167)***	7.06	6.00	(-2.138)**	65.6	72.6	(1.1774)
	all	4.27	4.35	(0.518)	4.95	5.31	(1.693)	196.6	216.6	(1.1691)
Buyside	active	10.73	11.17	(1.841)*	-2.68	-2.40	(1.004)	314.8	345.8	(2.1135)**
	passive	-9.94	-9.98	(-0.247)	3.28	2.89	(-1.747)*	182.8	197.7	(1.6449)
	all	2.46	2.93	(6.228)***	-0.345	-0.371	(-0.167)	497.6	543.4	(2.7656)***
Sellside	active	11.47	11.85	(2.435)**	-1.72	-2.36	(-2.108)**	109.5	134.1	(1.5962)
	passive	-10.87	-11.23	(-1.766)*	2.31	1.58	(-2.253)**	67.2	67.9	(0.1854)
	all	0.600	0.794	(0.968)	-0.453	-1.182	(-2.771)***	176.1	202.2	(1.4365)
HFT	active	9.60	9.72	(1.066)	-2.51	-2.39	(0.481)	138.3	135.0	(-0.4107)
	passive	-12.59	-13.00	(-2.176)**	0.245	0.242	(-0.0196)	364.2	380.7	(0.9423)
	all	-7.04	-7.37	(-2.101)**	-0.533	-0.504	(0.210)	502.5	515.7	(0.5359)

**Panel B: HL ETF**

Segment	Side	VWES (bps)			VWRS (bps)			Volume (1000)		
		pre	post	t statistic	pre	post	t statistic	pre	post	t statistic
RET	active	8.43	9.13	(2.425)**	6.71	7.40	(1.623)	354.1	355.6	(0.0382)
	passive	-8.65	-8.74	(-0.415)	5.21	4.77	(-0.926)	174.1	176.2	(0.0998)
	all	4.56	4.91	(2.084)**	6.66	7.18	(1.280)	526.1	530.7	(0.0783)
Buyside	active	9.05	9.01	(-0.209)	-1.14	-1.27	(-0.288)	162.7	171.5	(0.700)
	passive	-8.84	-8.88	(-0.197)	0.323	3.95	(2.834)***	35.3	31.9	(-2.034)**
	all	5.42	5.77	(0.955)	-1.11	-1.38	(-0.712)	189.6	193.7	(0.350)
Sellside	active	9.01	9.30	(0.478)	6.66	4.69	(-1.327)	71.0	100.1	(1.291)
	passive	-8.80	-8.39	(0.903)	1.25	-1.21	(-2.251)**	34.7	38.4	(0.657)
	all	1.62	-0.45	(-2.509)**	3.66	0.977	(-2.786)***	99.3	103.5	(0.358)
HFT	active	8.36	8.48	(0.688)	-5.48	-5.03	(0.900)	350.2	399.0	(2.337)**
	passive	-8.68	-9.12	(-1.493)	-3.17	-3.37	(-0.568)	584.3	595.1	(0.564)
	all	-3.57	-3.37	(0.895)	-4.23	-4.29	(-0.231)	930.0	989.4	(1.671)*



Table 12: Two Stage Regression on Retail Effective Spreads – TSX Comp

<b>Panel A: TSX Comp RET (A+P)</b>				
	<b>First Stage</b>		<b>Second Stage</b>	
	Dark	<i>t</i> statistic	VWES	<i>t</i> statistic
Intercept	0.194	(10.16)***	33.30	(16.03)***
rule change	$-3.91 \times 10^{-2}$	(-7.206)***		
$\widehat{Dark}$			-0.939	(-0.152)
Time	$6.96 \times 10^{-5}$	(0.645)	$1.077 \times 10^{-3}$	(0.2407)
log(\$Volume)	$-8.31 \times 10^{-3}$	(-5.248)***	-1.663	(-9.756)***
Volatility	$-1.89 \times 10^{-5}$	(-2.642)***	$1.396 \times 10^{-3}$	(1.062)
Price	$8.85 \times 10^{-5}$	(0.0941)	$-6.44 \times 10^{-4}$	(-0.0237)
Observations	19747		19594	
Adjusted R <sup>2</sup>	0.1461		0.3082	
Fixed Effects	Stock		Stock	

<b>Panel B: TSX Comp RET (A)</b>				
	<b>First Stage</b>		<b>Second Stage</b>	
	Dark	<i>t</i> statistic	VWES	<i>t</i> statistic
Intercept	0.121	(6.17)***	36.71	(8.134)***
rule change	$-3.85 \times 10^{-2}$	(-7.123)***		
$\widehat{Dark}$			-18.11	(-2.434)**
Time	$5.58 \times 10^{-5}$	(0.529)	$-2.38 \times 10^{-3}$	(-0.399)
log(\$Volume)	$-1.86 \times 10^{-3}$	(-1.080)	-1.01	(-1.770)*
Volatility	$-3.31 \times 10^{-5}$	(-4.271)***	$1.67 \times 10^{-2}$	(1.922)*
Price	$-3.35 \times 10^{-5}$	(-0.0384)	$-8.06 \times 10^{-2}$	(-1.017)
Observations	19747		19594	
Adjusted R <sup>2</sup>	0.1461		0.3082	
Fixed Effects	Stock		Stock	



Table 13: Two Stage Regression on HFT Effective Spreads – TSX Comp

**Panel A: TSX Comp HFT (A+P)**

	First Stage		Second Stage	
	Dark	t statistic	VWES	t statistic
Intercept	0.272	(7.60)***	-32.32	(-6.385)***
rule change	$-4.09 \times 10^{-2}$	(-7.617)***		
$\widehat{Dark}$			23.14	(4.229)***
Time	$1.32 \times 10^{-4}$	(1.235)	$1.10 \times 10^{-2}$	(2.168)**
log(\$Volume)	$-1.33 \times 10^{-2}$	(-4.777)***	1.13	(2.497)**
Volatility	$-1.46 \times 10^{-5}$	(-2.205)***	$-1.09 \times 10^{-2}$	(-2.438)**
Price	$3.57 \times 10^{-4}$	(0.342)	$7.56 \times 10^{-2}$	(1.096)
Observations	19757		19594	
Adjusted R <sup>2</sup>	0.1478		0.6671	
Fixed Effects	Stock		Stock	

**Panel A: TSX Comp HFT (P)**

	First Stage		Second Stage	
	Dark	t statistic	VWES	t statistic
Intercept	0.292	(8.44)***	-51.95	(-7.125)***
rule change	$-4.09 \times 10^{-2}$	(-7.610)***		
$\widehat{Dark}$			24.35	(4.814)***
Time	$1.33 \times 10^{-4}$	(1.250)	$8.94 \times 10^{-3}$	(1.601)
log(\$Volume)	$-1.51 \times 10^{-2}$	(-5.611)***	1.96	(2.807)***
Volatility	$-1.12 \times 10^{-5}$	(-1.736)*	$-1.82 \times 10^{-2}$	(-2.249)**
Price	$3.67 \times 10^{-4}$	(0.3534)	$4.69 \times 10^{-2}$	(0.601)
Observations	19757		19757	
Adjusted R <sup>2</sup>	0.1497		0.6725	
Fixed Effects	Stock		Stock	



Table 14: Two Stage Regression on Retail Effective Spreads - HL ETF

<b>Panel A: HL ETF RET (A+P)</b>				
	<b>First Stage</b>		<b>Second Stage</b>	
	Dark	<i>t</i> statistic	VWES	<i>t</i> statistic
Intercept	0.083	(1.20)	16.09	(7.95)***
rule change	-0.159	(-11.17)***		
$\widehat{Dark}$			-1.53	(-1.23)
Time	$2.60 \times 10^{-4}$	(1.84)*	$5.30 \times 10^{-3}$	(1.19)
log(\$Volume)	$2.84 \times 10^{-3}$	(0.622)	-0.417	(-3.51)***
Volatility	$-5.44 \times 10^{-6}$	(-0.486)	$-1.62 \times 10^{-3}$	(-1.62)
Price	$5.63 \times 10^{-4}$	(0.879)	-0.299	(-12.68)***
Observations	3603		3603	
Adjusted R <sup>2</sup>	0.6175		0.478	
Fixed Effects	Stock		Stock	

<b>Panel B: HL ETF RET (A)</b>				
	<b>First Stage</b>		<b>Second Stage</b>	
	Dark	<i>t</i> statistic	VWES	<i>t</i> statistic
Intercept	-0.0049	(-0.065)	15.71	(5.94)***
rule change	-0.159	(-11.20)***		
$\widehat{Dark}$			-3.36	(-2.36)**
Time	$2.60 \times 10^{-4}$	(1.87)*	$9.57 \times 10^{-3}$	(2.05)**
log(\$Volume)	$8.66 \times 10^{-3}$	(1.75)*	$-2.11 \times 10^{-2}$	(-0.159)
Volatility	$-1.4 \times 10^{-5}$	(-1.20)	$5.04 \times 10^{-4}$	(0.792)
Price	$6.11 \times 10^{-4}$	(0.939)	-0.529	(-7.86)***
Observations	3603		3603	
Adjusted R <sup>2</sup>	0.6186		0.8969	
Fixed Effects	Stock		Stock	



Table 15: Two Stage Regression on HFT Effective Spreads - HL ETF

**Panel A: HL ETF HFT (A+P)**

	First Stage		Second Stage	
	Dark	t statistic	VWES	t statistic
Intercept	0.397	(7.27)***	-22.80	(-8.65)***
rule change	-0.160	(-11.04)***		
$\widehat{Dark}$			-0.615	(-0.373)
Time	$2.81 \times 10^{-4}$	(1.85)*	$3.32 \times 10^{-3}$	(0.531)
log(\$Volume)	$-2.06 \times 10^{-2}$	(-4.91)***	0.714	(3.81)***
Volatility	$3.26 \times 10^{-5}$	(2.39)**	$1.29 \times 10^{-4}$	(0.214)
Price	$1.33 \times 10^{-3}$	(1.90)*	0.444	(26.42)***
Observations	3603		3603	
Adjusted R <sup>2</sup>	0.6301		0.4786	
Fixed Effects	Stock		Stock	

**Panel B: HL ETF HFT (P)**

	First Stage		Second Stage	
	Dark	t statistic	VWES	t statistic
Intercept	0.357	(6.85)***	-19.77	-12.56***
rule change	-0.160	(-11.09)***		
$\widehat{Dark}$			2.39	(1.82)*
Time	$2.69 \times 10^{-4}$	(1.80)*	$-7.04 \times 10^{-3}$	(-1.68)*
log(\$Volume)	$-1.73 \times 10^{-2}$	(-4.41)***	0.230	(2.56)**
Volatility	$2.63 \times 10^{-5}$	(2.07)**	$-6.08 \times 10^{-4}$	(-1.17)
Price	$9.76 \times 10^{-4}$	(1.46)	0.592	(9.69)***
Observations	3603		3603	
Adjusted R <sup>2</sup>	0.6262		0.9145	
Fixed Effects	Stock		Stock	





Table 16: Market Depth in Trading Increments - TSX Comp

<b>Panel A: Lit Depth (log(shares))</b>			
	<b>pre</b>	<b>post</b>	<b>t statistic</b>
Level 0	5.68	5.70	(2.75)***
NBB NBO	5.64	5.66	(2.37)**
Level 2	5.63	5.64	(0.20)
Level 3	5.66	5.64	(-1.07)
Level 4	5.64	5.62	(-1.51)
Level 5	5.68	5.70	(2.75)***

<b>Panel B: Dark Depth (log(shares))</b>			
	<b>pre</b>	<b>post</b>	<b>t statistic</b>
Level 0	5.50	5.10	(-12.22)***
NBB NBO	4.94	4.77	(-7.53)***
Level 2	4.73	4.46	(-9.68)***
Level 3	4.50	4.20	(-8.77)***
Level 4	4.36	4.06	(-8.02)***
Level 5	4.28	3.98	(-7.84)***

<b>Panel C: Overall Depth (log(shares))</b>			
	<b>pre</b>	<b>post</b>	<b>t statistic</b>
Level 0	5.50	5.10	(-12.15)***
NBB NBO	5.79	5.80	(1.13)
Level 2	5.73	5.73	(0.855)
Level 3	5.71	5.70	(-0.629)
Level 4	5.71	5.70	(-1.28)
Level 5	5.69	5.67	(-1.59)



Table 17: Second Stage Regression on Lit Market Depth - TSX Comp

<b>TSX Comp Lit</b>				
<b>variables</b>	<b>NBBO</b>		<b>level 2</b>	
	<b>coefficient</b>	<b>t statistic</b>	<b>coefficient</b>	<b>t statistic</b>
Intercept	3.96	(34.03)***	4.29	(33.89)***
$\widehat{Dark}$	-1.27	(-2.96)***	-0.55	(-1.33)
Time	$-5.46 \times 10^{-4}$	(-1.81)*	$-9.86 \times 10^{-5}$	(-0.36)
log(\$Volume)	0.19	(22.22)***	0.178	(18.64)***
Volatility	$-5.94 \times 10^{-4}$	(-8.40)***	$-5.36 \times 10^{-4}$	(-7.36)***
Price	$-1.17 \times 10^{-2}$	(-2.98)***	$-1.33 \times 10^{-2}$	(-4.47)***
Observations	19646		19648	
Adjusted R <sup>2</sup>	0.8378		0.8948	
Fixed Effects	Stock		Stock	



Table 18: Second Stage Regression on Dark Market Depth - TSX Comp

<b>TSX Comp Dark</b>						
variables	level 0		NBBO		level 2	
	coefficient	t statistic	coefficient	t statistic	coefficient	t statistic
Intercept	0.57	(1.50)	-0.99	(2.78)***	-0.94	(-2.38)**
$\widehat{Dark}$	11.16	(7.97)***	5.70	(4.13)***	9.82	(7.85)***
Time	$-5.07 \times 10^{-4}$	(-0.57)	$3.81 \times 10^{-4}$	(0.42)	$3.16 \times 10^{-4}$	(0.38)
log(\$Volume)	0.29	(11.64)***	0.29	(13.79)***	0.37	(14.24)***
Volatility	$1.26 \times 10^{-4}$	(1.42)	$-4.48 \times 10^{-4}$	(-5.24)***	$-2.01 \times 10^{-4}$	(-2.22)**
Price	$-5.42 \times 10^{-3}$	(-0.80)	$-1.46 \times 10^{-2}$	(-3.99)***	$-1.39 \times 10^{-2}$	(-3.39)***
Observations	19669		19669		19669	
Adjusted R <sup>2</sup>	0.3025		0.4077		0.3448	
Fixed Effects	Stock		Stock		Stock	

<b>TSX Comp Dark continued</b>						
variables	level 3		level 4		level 5	
	coefficient	t statistic	coefficient	t statistic	coefficient	t statistic
Intercept	-3.15	(-6.14)***	-4.44	(-7.26)***	-5.73	(-9.03)***
$\widehat{Dark}$	12.86	(7.59)***	14.77	(7.49)***	16.08	(7.04)***
Time	$1.49 \times 10^{-4}$	(0.14)	$-6.17 \times 10^{-5}$	(-0.054)	$1.72 \times 10^{-4}$	(0.14)
log(\$Volume)	0.44	(14.16)***	0.50	(13.59)***	0.54	(14.51)***
Volatility	$1.90 \times 10^{-4}$	(-1.57)	$5.57 \times 10^{-4}$	(3.80)***	$9.18 \times 10^{-4}$	(5.22)***
Price	$-9.57 \times 10^{-3}$	(-1.96)	$-4.93 \times 10^{-3}$	(-0.84)	$-2.69 \times 10^{-3}$	(-0.39)
Observations	19669		19669		19669	
Adjusted R <sup>2</sup>	0.2702		0.2483		0.2431	
Fixed Effects	Stock		Stock		Stock	



Table 19: Second Stage Regression on Overall Market Depth - TSX Comp

**Panel A: TSX Comp**

variables	level 0		NBBO		level 2	
	coefficient	t statistic	coefficient	t statistic	coefficient	t statistic
Intercept	0.743	(2.09)**	3.86	(34.28)***	4.17	(35.41)***
$\widehat{Dark}$	10.92	(8.90)***	-0.602	(-1.39)	$-1.76 \times 10^{-2}$	(-0.046)
Time	$-4.06 \times 10^{-4}$	(-0.526)	$-3.72 \times 10^{-4}$	(-1.24)	$4.89 \times 10^{-5}$	(0.195)
log(\$Volume)	0.278	(12.23)***	0.203	(24.58)***	0.185	(20.48)***
Volatility	$-1.16 \times 10^{-4}$	(1.39)	$-6.22 \times 10^{-4}$	(-8.44)***	$-5.51 \times 10^{-4}$	(-7.36)***
Price	$-5.62 \times 10^{-3}$	(-0.855)	$-1.20 \times 10^{-2}$	(-3.39)***	$-1.30 \times 10^{-2}$	(-4.48)***
Observations	19608		19757		19641	
Adjusted R <sup>2</sup>	0.3145		0.8240		0.8835	
Fixed Effects	Stock		Stock		Stock	

**Panel A: TSX Comp continued**

variables	level 3		level 4		level 5	
	coefficient	t statistic	coefficient	t statistic	coefficient	t statistic
Intercept	4.39	(34.60)**	4.59	(31.49)***	4.49	(31.75)***
$\widehat{Dark}$	0.376	(0.984)	0.512	(1.02)	0.901	(1.83)*
Time	$1.25 \times 10^{-4}$	(0.520)	$5.51 \times 10^{-5}$	(0.180)	$2.86 \times 10^{-4}$	(0.926)
log(\$Volume)	0.168	(18.72)***	0.153	(16.01)***	0.155	(16.10)***
Volatility	$-4.79 \times 10^{-4}$	(-6.53)***	$-4.33 \times 10^{-4}$	(-6.41)***	$-4.20 \times 10^{-4}$	(-6.38)***
Price	$-1.15 \times 10^{-3}$	(-4.16)***	$-9.30 \times 10^{-3}$	(-3.20)***	$-1.08 \times 10^{-2}$	(-3.55)***
Observations	19646		19647		19640	
Adjusted R <sup>2</sup>	0.8979		0.8938		0.8874	
Fixed Effects	Stock		Stock		Stock	



Table 20: Market Depth in Trading Increments - HL ETF

**Panel A: Lit Depth (log(shares))**

	pre	post	t statistic
Level 0			
NBB NBO	6.87	6.94	(3.80)***
Level 2	7.17	7.24	(3.90)***
Level 3	7.18	7.22	(3.24)***
Level 4	7.10	7.13	(1.71)*
Level 5	6.97	6.97	(-0.073)

**Panel B: Dark Depth (log(shares))**

	pre	post	t statistic
Level 0	6.18	5.03	(-10.58)***
NBB NBO	5.63	4.05	(-9.61)***
Level 2	5.33	4.20	(-4.57)***
Level 3	5.40	4.39	(-3.54)***
Level 4	5.55	4.79	(-3.25)***
Level 5	5.51	4.57	(-2.96)***

**Panel C: Overall Depth (log(shares))**

	pre	post	t statistic
Level 0	6.09	4.98	(-9.80)***
NBB NBO	6.91	6.95	(1.70)*
Level 2	7.18	7.24	(3.20)***
Level 3	7.18	7.22	(2.36)**
Level 4	7.11	7.13	(0.921)
Level 5	6.98	6.97	(-0.459)



Table 21: Second Stage Regression on Lit Market Depth - HL ETF

HL ETF Lit						
variables	NBBO		level 2		level 3	
	coefficient	t statistic	coefficient	t statistic	coefficient	t statistic
Intercept	6.77	(22.71)***	7.17	(28.51)***	7.27	(35.46)***
<i>Dark</i>	-0.77	(-2.96)***	-0.52	(-2.18)**	-0.11	(-0.61)
Time	$6.78 \times 10^{-4}$	(-1.59)	$9.72 \times 10^{-4}$	(2.60)**	$1.01 \times 10^{-3}$	(3.12)***
log(\$Volume)	$4.21 \times 10^{-2}$	(2.80)***	$2.18 \times 10^{-2}$	(1.85)*	$9.11 \times 10^{-3}$	(0.94)
Volatility	$-1.70 \times 10^{-4}$	(-3.82)***	$-1.03 \times 10^{-4}$	(-2.53)**	$-6.95 \times 10^{-5}$	(-1.82)*
Price	$-1.85 \times 10^{-2}$	(-2.21)**	$-1.76 \times 10^{-2}$	(-2.49)**	$-1.53 \times 10^{-2}$	(-2.70)***
Observations	3603		3603		3603	
Adjusted R <sup>2</sup>	0.9110		0.9284		0.9308	
Fixed Effects	Stock		Stock		Stock	



Table 22: Second Stage Regression on Dark Market Depth - HL ETF

<b>HL ETF Dark</b>						
<b>variables</b>	<b>level 0</b>		<b>NBBO</b>		<b>level 2</b>	
	<b>coefficient</b>	<b>t statistic</b>	<b>coefficient</b>	<b>t statistic</b>	<b>coefficient</b>	<b>t statistic</b>
Intercept	1.38	(1.64)	-3.49	(22.71)***	-7.43	(-4.22)***
$\widehat{Dark}$	15.60	(10.14)***	30.78	(-2.96)***	34.79	(-8.17)***
Time	-4.11×10 <sup>-3</sup>	(-1.66)*	-9.72×10 <sup>-3</sup>	(1.59)	-1.60×10 <sup>-2</sup>	(-4.08)***
log(\$Volume)	0.268	(5.43)***	0.43	(2.80)***	0.53	(5.14)***
Volatility	-4.07×10 <sup>-4</sup>	(-3.66)***	-1.06×10 <sup>-3</sup>	(-3.82)***	-9.88×10 <sup>-4</sup>	(-3.45)***
Price	-4.65×10 <sup>-2</sup>	(-5.74)***	-3.95×10 <sup>-2</sup>	(-2.21)**	-2.05×10 <sup>-2</sup>	(-0.86)
Observations	3020		3512		3512	
Adjusted R <sup>2</sup>	0.7975		0.7071		0.6963	
Fixed Effects	Stock		Stock		Stock	

<b>HL ETF Dark continued</b>						
<b>variables</b>	<b>level 3</b>		<b>level 4</b>		<b>level 5</b>	
	<b>coefficient</b>	<b>t statistic</b>	<b>coefficient</b>	<b>t statistic</b>	<b>coefficient</b>	<b>t statistic</b>
Intercept	-4.45	(2.24)**	-3.26	(-1.64)	-2.92	(-1.40)
$\widehat{Dark}$	30.27	(6.59)***	28.34	(5.91)***	26.05	(5.54)***
Time	-1.71×10 <sup>-2</sup>	(-4.34)***	-1.55×10 <sup>-2</sup>	(-4.49)***	-1.51×10 <sup>-2</sup>	(-4.36)***
log(\$Volume)	0.37	(3.11)***	0.30	(2.49)**	0.27	(2.07)**
Volatility	-5.92×10 <sup>-4</sup>	(-1.97)*	-3.63×10 <sup>-4</sup>	(-1.19)	-3.77×10 <sup>-4</sup>	(-1.60)
Price	-7.57×10 <sup>-2</sup>	(-5.17)***	-8.38×10 <sup>-2</sup>	(-5.64)***	-7.00×10 <sup>-2</sup>	(-3.95)***
Observations	3512		3512		3512	
Adjusted R <sup>2</sup>	0.6707		0.6712		0.6703	
Fixed Effects	Stock		Stock		Stock	



Table 23: Second Stage Regression on Overall Market Depth - HL ETF

HL ETF Overall						
variables	level 0		NBBO		level 2	
	coefficient	t statistic	coefficient	t statistic	coefficient	t statistic
Intercept	1.38	(1.64)	6.64	(23.45)***	7.13	(29.83)***
$\widehat{Dark}$	15.60	(10.14)***	0.071	(0.323)	-0.265	(-1.22)
Time	$-4.11 \times 10^{-3}$	(-1.66)*	$7.13 \times 10^{-4}$	(1.70)*	$9.20 \times 10^{-4}$	(2.52)**
log(\$Volume)	0.268	(5.43)***	$4.99 \times 10^{-2}$	(3.50)***	$2.43 \times 10^{-2}$	(2.11)**
Volatility	$-4.07 \times 10^{-4}$	(-3.66)***	$-1.46 \times 10^{-4}$	(-3.91)***	$-9.61 \times 10^{-5}$	(-2.58)***
Price	$-4.65 \times 10^{-2}$	(-5.74)***	$-1.93 \times 10^{-2}$	(-2.35)***	$-1.82 \times 10^{-2}$	(-2.85)***
Observations	3020		3603		3603	
Adjusted R <sup>2</sup>	0.7975		0.9200		0.9313	
Fixed Effects	Stock		Stock		Stock	

HL ETF Overall continued						
variables	level 3		level 4		level 5	
	coefficient	t statistic	coefficient	t statistic	coefficient	t statistic
Intercept	7.26	(36.36)***	7.18	(33.81)***	6.83	(28.90)***
$\widehat{Dark}$	$9.78 \times 10^{-2}$	(0.534)	0.241	(1.34)	0.476	(2.10)**
Time	$9.25 \times 10^{-4}$	(2.94)***	$6.69 \times 10^{-4}$	(1.64)	$5.32 \times 10^{-4}$	(0.984)
log(\$Volume)	$9.63 \times 10^{-3}$	(0.989)	$6.51 \times 10^{-3}$	(0.661)	$1.07 \times 10^{-2}$	(0.858)
Volatility	$-6.50 \times 10^{-5}$	(-1.77)*	$-5.02 \times 10^{-5}$	(-1.36)	$-5.82 \times 10^{-5}$	(-1.61)
Price	$-1.56 \times 10^{-2}$	(-3.02)***	$-1.26 \times 10^{-2}$	(-2.30)**	$-8.78 \times 10^{-3}$	(-1.73)*
Observations	3603		3603		3603	
Adjusted R <sup>2</sup>	0.932		0.9152		0.8756	
Fixed Effects	Stock		Stock		Stock	





Table 24: Volatility

<b>Panel A: TSX Comp</b>			
	pre	post	t statistic
1 minutes	0.0007280	0.0007664	(2.0934)**
5 minutes	0.001592	0.001615	(0.5370)
30 minutes	0.003507	0.003468	(-0.3711)

<b>Panel B: HL ETF</b>			
	pre	post	t statistic
1 minutes	0.0005556	0.0005279	(-1.6600)*
5 minutes	0.001165	0.001105	(-1.5683)
30 minutes	0.002610	0.002484	(-1.0651)



Table 25: Return Autocorrelation

<b>Panel A: TSX Comp</b>			
	<b>pre</b>	<b>post</b>	<b>t statistic</b>
10 seconds	0.0500	0.0554	(2.688)***
30 seconds	0.0770	0.0878	(3.225)***
60 seconds	0.0960	0.108	(3.172)***

<b>Panel C: HL ETF</b>			
	<b>pre</b>	<b>post</b>	<b>t statistic</b>
10 seconds	0.0309	0.0300	(-0.627)
30 seconds	0.0611	0.0613	(0.0774)
60 seconds	0.0878	0.0895	(0.605)



Table 26: Second Stage Regression on Autocorrelation and Volatility

<b>Panel A: TSX Comp</b>				
<b>variables</b>	<b>Autocorrelation</b>		<b>Volatility</b>	
	<b>coefficient</b>	<b>t statistic</b>	<b>coefficient</b>	<b>t statistic</b>
Intercept	-0.960	(-2.01)**	-11.86	(-10.90)***
$\widehat{Dark}$	-6.19	(-4.01)***	-2.93	(-1.17)
Time	$-1.04 \times 10^{-3}$	(-0.976)	$-8.80 \times 10^{-4}$	(-0.505)
log(\$Volume)	0.105	(3.65)***	0.916	(12.05)***
Volatility				
Price	$1.72 \times 10^{-2}$	(2.80)***	$-6.21 \times 10^{-2}$	(-1.99)**
Observations	19757		19757	
Adjusted R <sup>2</sup>	0.0502		0.6212	
Fixed Effects	Stock		Stock	

<b>Panel B: HL ETF</b>				
<b>variables</b>	<b>Autocorrelation</b>		<b>Volatility</b>	
	<b>coefficient</b>	<b>t statistic</b>	<b>coefficient</b>	<b>t statistic</b>
Intercept	0.687	(0.741)	-6.56	(-19.81)***
$\widehat{Dark}$	-1.01	(-0.768)	0.884	(1.73)*
Time	$-9.99 \times 10^{-4}$	(-0.447)	$4.23 \times 10^{-4}$	(0.560)
log(\$Volume)	$-9.23 \times 10^{-2}$	(-1.52)	0.357	(18.54)***
Volatility				
Price	$-8.64 \times 10^{-3}$	(-2.11)**	$-1.48 \times 10^{-2}$	(-2.77)***
Observations	3603		3603	
Adjusted R <sup>2</sup>	0.2540		0.8745	
Fixed Effects	Stock		Stock	



Table 27: Diversity of Liquidity Provision (Inverse HI)

<b>Panel A: TSX Comp</b>			
	<b>pre</b>	<b>post</b>	<b>t statistic</b>
Lit + Dark	35.96	31.00	(-7.795)***
Lit	33.94	28.13	(-10.193)***
Dark	10.82	32.53	(20.452)***
Dark – ALF only	2.09	2.74	(2.440)**
Dark – CHX only	11.68	10.81	(-2.264)**
Dark – TCM only	17.59	22.55	(4.09)***
Dark – TSX only	16.39	18.98	(2.10)**

<b>Panel B: HL ETF</b>			
	<b>pre</b>	<b>post</b>	<b>t statistic</b>
Lit + Dark	15.81	15.40	(-0.909)
Lit	15.12	14.99	(-0.275)
Dark	9.05	4.52	(-16.008)***
Dark – ALF only	7.89	1.07	(-38.36)***
Dark – CHX only	4.25	4.24	(-0.0050)
Dark – TCM only	1.05	1.64	(3.530)***
Dark – TSX only	2.29	1.93	(-1.004)



Table 28: Top Ranked Liquidity Providers in the Dark

**Panel A: TSX Comp**

Entity ID	Broker	segment	Dark					Lit + Dark				
			Rank (pre)	Rank (post)	pre (m)	Post (m)	t statistic	Rank (pre)	Rank (post)	pre (m)	Post (m)	t statistic
User 08	A	HFT	1	88	113.069	0.605	-23.24***	8	136	121.25	4.123	-25.235***
User 01	E	HFT	2	5	45.342	11.124	-21.728***	1	1	290.988	369.603	5.295***
User 02	C	HFT	3	2	32.989	17.073	-12.602***	2	2	278.569	324.14	3.537***
User 17	I	SB	4	1	23.656	29.967	2.684***	17	16	36.986	46.171	2.828***
User 21	A, B, I	SB	5	4	18.485	13.537	-2.666***	25	29	25.107	18.837	-2.761***

**Panel B: HL ETF**

Entity ID	Broker	segment	Dark					Lit + Dark				
			Rank (pre)	Rank (post)	pre (m)	post (m)	t statistic	Rank (pre)	Rank (post)	pre (m)	Post (m)	t statistic
User 11	D	HFT	1	11	11.56	0.157	-15.072***	2	4	35.138	24.303	-3.928***
User 02	C	HFT	2	6	11.42	0.318	-22.36***	3	3	34.922	28.134	-2.517**
User 08	A	HFT	3	8	11.05	0.188	-17.339***	10	44	11.328	1.747	-14.623***
User 01	E	HFT	4	5	9.895	0.647	-19.789***	4	2	32.194	46.57	5.111***
User 04	C	HFT	5	3	9.872	1.039	-14.157***	1	1	82.917	87.35	0.955



Table 29: Market Met Internalization by Broker (% of Overall Trading in Dark and Lit)

<b>Panel A: TSX Comp</b>						
	<b>Daily Value (\$1 m)</b>			<b>Daily %</b>		
	pre	post	t statistic	pre	post	t statistic
ALL	142.5	100.4	(-3.312)***	2.75	1.81	(-5.59)***
A	64.2	15.9	(-14.66)***	10.76	2.90	(-13.80)***
B	21.2	19.7	(-0.645)	5.17	4.38	(-1.92)*
C	18.7	19.8	(0.351)	1.58	1.63	(0.206)
D	6.5	11.4	(0.832)	3.24	6.24	(0.797)
E	11.7	12.5	(0.842)	1.91	1.85	(-0.627)
F	4.74	5.11	(0.379)	1.58	1.61	(0.096)
G	3.57	3.72	(0.194)	1.65	1.37	(-1.061)
H	3.29	3.84	(0.881)	2.54	2.87	(0.804)
I	2.98	3.40	(1.038)	2.09	2.37	(1.276)
Remainder	5.68	5.04	(-0.974)	0.47	0.38	(-1.811)*

<b>Panel B: HL ETF</b>						
	<b>Daily Value (\$1 m)</b>			<b>Daily %</b>		
	pre	post	t statistic	pre	post	t statistic
ALL	29.9	30.4	(0.220)	6.11	5.95	(-0.446)
A	8.93	5.46	(-3.497)***	13.01	7.16	(-6.997)***
B	8.05	10.34	(3.033)***	15.25	17.71	(2.124)**
C	4.94	5.42	(0.484)	3.56	3.95	(0.573)
D	4.67	4.92	(0.216)	6.46	6.94	(0.369)
E	0.286	0.208	(-0.515)	0.832	0.411	(-0.820)
F	2.04	3.10	(4.164)***	6.66	10.48	(4.845)***
G	0.495	0.664	(1.466)	2.34	3.28	(1.813)*
H	0.027	0.013	(-0.938)	0.973	0.324	(-1.569)
I	0.772	0.775	(0.0083)	11.41	8.29	(-0.786)
Remainder	0.166	0.139	(-0.634)	0.290	0.229	(-0.866)



Table 30: Market Met Internalization by Entity ID (Dark plus Lit Value)

Panel A: TSX Comp				Daily Value (\$100 m)		
Entity ID	Segment	Broker	Side	pre	post	t statistic
User 08	HFT	A	Principal	490.02	22.5	(-23.099)***
User 01	Sellside	E	Principal	63.72	52.58	(-3.477)***
User 05	Sellside	H	Principal	32.89	36.06	(0.528)
User 48	Sellside	A	Principal	29.79	27.17	(-0.661)
User 49	Sellside	A	Principal	28.38	8.9	(-15.737)***
User 13	RET	A	Client	269.06	44.4	(-20.763)***
User 14	RET	A	Client	204.78	38.42	(-18.217)***
User 50	RET	A	Client	92.52	8.39	(-20.156)***
User 04	HFT	C	Client	35.15	39.83	(0.969)
User 07	HFT	E	Client	33.03	15.04	(-4.438)***
Panel B: HL ETF				Daily Value (\$100 m)		
Entity ID	Segment	Broker	Side	pre	post	t statistic
User 11	HFT	D	Principal	91.14	92.64	(0.063)
User 08	HFT	A	Principal	65.79	10.37	(-13.41)***
User 35	HFT	B	Principal	31.01	29.91	(-0.508)
User 33	HFT	F	Principal	26.79	44.66	(4.239)***
User 37	HFT	B	Principal	25.61	43.16	(4.899)***
User 13	RET	A	Client	100.81	31	(-10.474)***
User 39	RET	B	Client	31.42	26.37	(-2.196)**
User 04	HFT	C	Client	28.53	30.09	(0.213)
User 50	RET	A	Client	24.34	1.67	(-14.604)***
User 51	Buyside	D	Client	18.46	NA	NA



Table 31: % and value of MMI of Retail and non-Retail Clients

**Panel A: TSX Comp**

	% of Category			Value (millions)		
	Pre	Post	t Statistic	Pre	Post	t Statistic
Retail	8.2	2.9	(-33.8)***	73.2	26.5	(-15.6)***
Non-Retail	2.2	1.5	(-9.5)***	162.0	122.5	(-5.4)***

**Panel B: HL ETF**

	% of Category			Value (millions)		
	Pre	Post	t Statistic	Pre	Post	t Statistic
Retail	8.9	9.2	(0.62)	17.3	17.6	(0.33)
Non-Retail	8.1	7.8	(-0.41)	39.6	41.0	(0.36)





## 8. Appendix C: Figures

Figure 7: Top 20 LPs Ranked by Overall Liquidity Provision in HL ETF

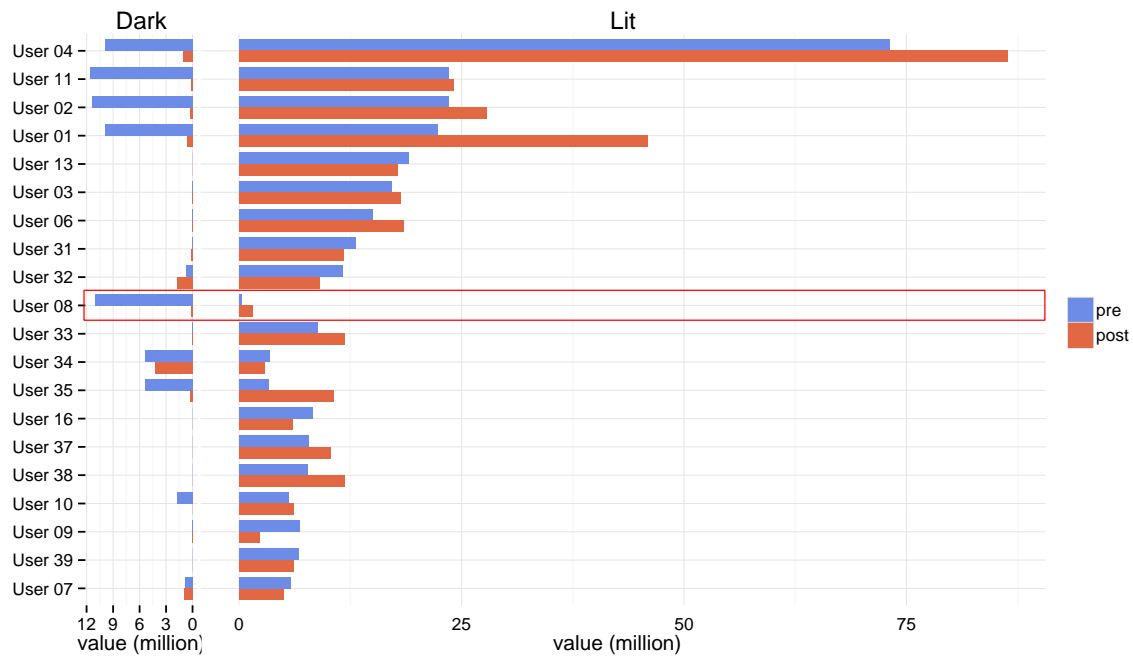


Figure 8: Top 20 LPs Ranked by Dark Liquidity Provision in HL ETF

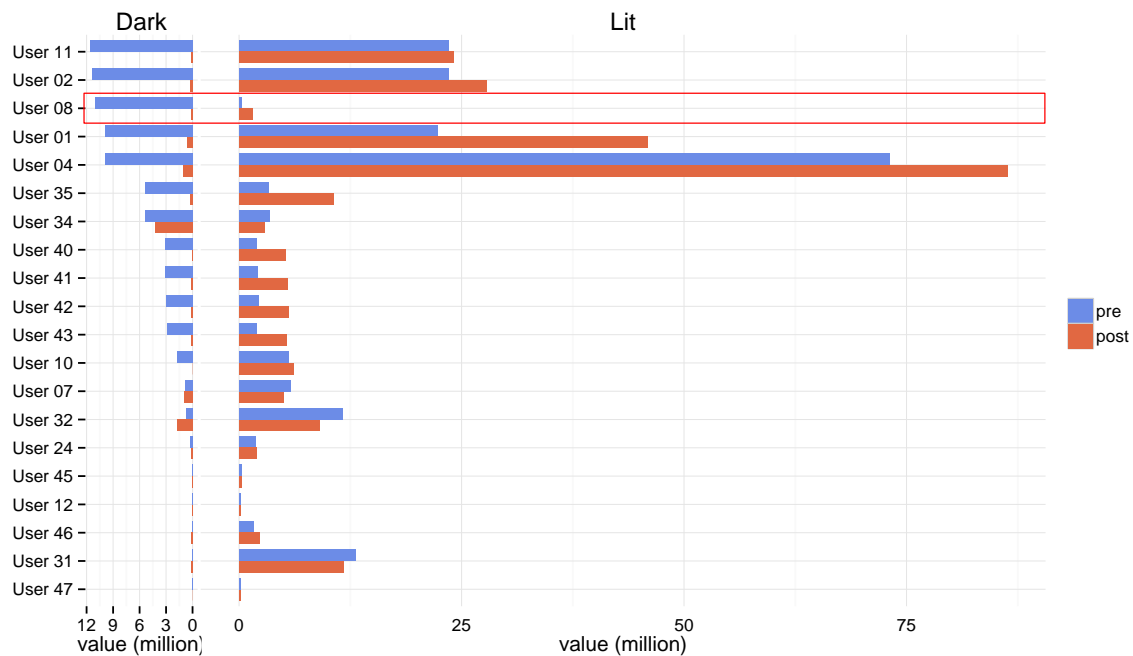
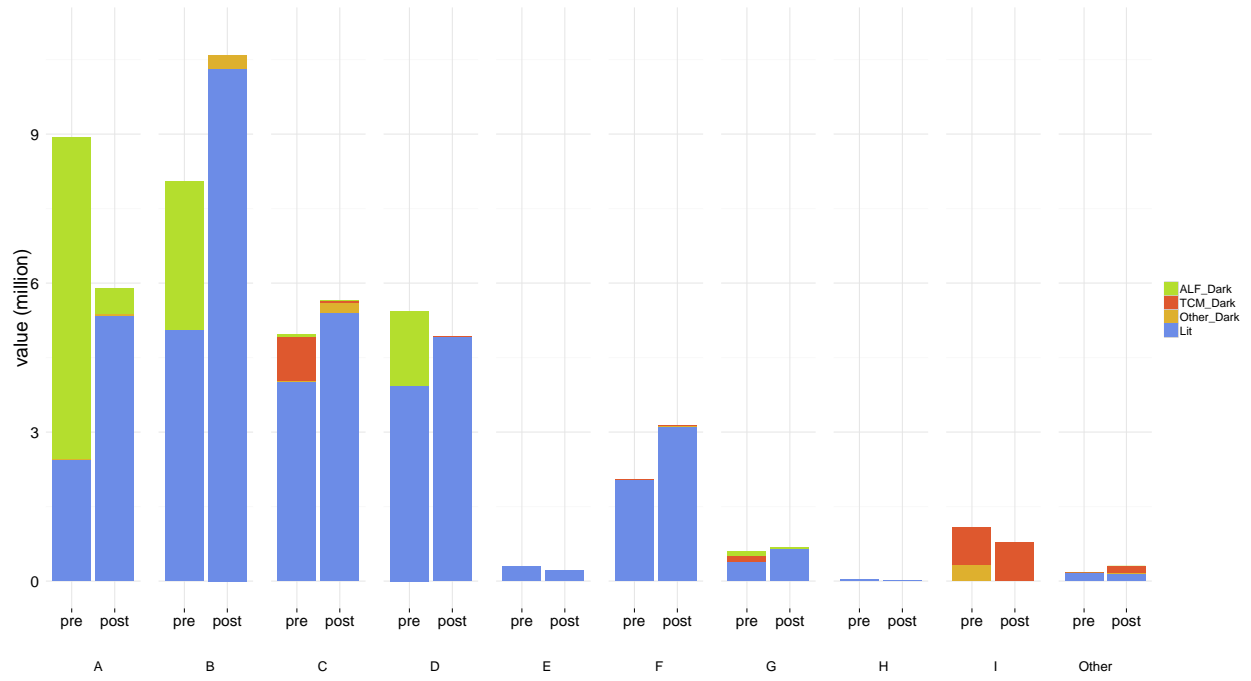




Figure 9: MMI in HL ETF by Broker and Traded Marketplace





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