Automated Trading in Futures Markets — Update #2[*]

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Introduction

In March of 2015, the CFTC released a white paper detailing the use of automation in futures markets.[1] The paper analyzed the prevalence of automation across different asset classes, the relationship between market speed and the use of automation, and how automation is used when providing and taking liquidity. In almost all contracts, the level of automation during the analyzed two year time frame increased, sometimes significantly, and one measure of market speed, the average time between the submission of an order and its execution, also experienced a coincident increase (i.e. the average time decreased). Two years later, the paper was updated with data through the end of October 2016.[2]

This update further extends the time series by an additional two years, updating all tables and figures. For tables with two sets of results, numbers in black represent information for the prior two year period (November 1, 2014 to October 31, 2016) and numbers in red represent information for the new two year period (November 1, 2016 to October 31, 2018). Some figures show time series charts of the full six year period from 2012 to 2018. Like the prior update, this paper expands the level of coverage, with one livestock contract (live cattle) now included in the product-level tables. Further information about the measures and the data sets used to generate this analysis can be found in the original white paper.

Prevalence of Automated Trading

The level of automated trading has continued to increase across all of the major product groups. Table 1 shows a breakdown of traded volume, by product group, into three distinct groups: non-electronic, automated (ATS), and manual.[3] Non-electronic volume includes block trading (done on a bilateral basis) as well as trades that occur in futures pits; all other trading, which is done on the electronic platform, is then divided into automated and manual components. Of the major product groups, increases in the level of automation were largest for metals contracts (54.1 to 67.6 percent automated, a group that includes gold, silver and copper) and energy (57.5 to 66.5 percent automated). Agricultural products experienced a slightly lower 7 percent increase in automation. The product groups which began the period with the highest levels of automation (e.g. interest rates, FX, and equities) saw smaller automation increases.

Drilling down into the more granular CME defined product subgroups shows similar trends. Table 2 provides a breakdown at the subgroup level. Like the group level breakdown documented in Table 1, the level of automation across subgroups has increased relative to the prior two year period. The largest increases were seen in livestock (45.8 to 59.5 percent automated) and metals (56.9 to 70.0 percent automated and 53.5 to 67.1 percent automated for base and precious metal subgroups, respectively). Biofuels is the only subgroup with a decrease in automated trading, with a coincident increase in activity in the non-electronic market. Coal and electricity subgroups continue to have all volume linked to non-electronic trading. We find only one subgroup, the equities select sector index, with an increase in the share of electronic manual trading compared to the prior two year sample. This subgroup includes products related to specific sectors of the E-mini S&P such as technology and consumer staples.

Table 3 starts the analysis of individual futures products by showing total volume and market share linked to automated and manual trading. For each product, we show the prior two year sample period next to the current two year sample period. This table has been updated to now include two columns showing total volume shares linked to automated and manual trading generally (Table 2 shows similar information, but at the product group level). We find only one product with a decrease in automated trading – the E-mini NASDAQ 100 futures contract. Though increases in automated trading are commonly associated with increases in trading volume, total volume in this increasingly manual futures market increased from 134 to 176 million contracts. In contrast, the total volume linked to the E-mini S&P 500 decreased from the prior sample, though the share of automated trading increased. In general, we do find large percent increases in total volume (e.g., silver: 52%; crude oil: 36%; live cattle: 23%) for contracts with large increases in automated trading.

The table also further divides total volume into three groups: trades with an automated trader on both sides (ATS–ATS), with one automated and one manual (ATS–MAN), and with both manual (MAN–MAN). Apart from, again, the E-mini NASDAQ 100, all products show an increase in ATS–ATS volume. Live cattle shows the largest

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[3]The table also contains the count of products found for each product group. The total number of products remained roughly flat across major products, except for the energy group where the product count fell from 275 to 236.

percentage increase in ATS–ATS volume with a 67% increase; copper follows with a 65% increase. Focusing on ATS–MAN, we find an increase of 15% for E-mini NASDAQ 100 and an increase of 4% and 2% for corn and soybeans, respectively. While the rest of the products show decreases in ATS–MAN, these tend to be smaller than the observed decreases in MAN–MAN, implying the majority of the increase in ATS–ATS is from manual traders switching to automated systems, or an increase in activity by already automated firms. The large volume shares linked to ATS–MAN indicate the potential usefulness of research investigating how automated trading systems interact with traders who continue to rely on non-automated systems.

Figure 1 provides a view into how volume shares linked to the three groups (ATS–ATS, ATS–MAN, and MAN–MAN) have changed over a six year time period. As in the tables, we find clear trends of decreasing MAN–MAN and ATS–MAN activity, with an increase in ATS–ATS. As noted in prior updates, the predictable cyclicality in these shares, most clearly observed in the E-mini S&P, Euro FX, and 10 Yr Treasury Note, results from the requirement to roll positions as contracts expire, a period when non-automated trading increases. Apart from these general trends, we do find differences across specific products. For both the E-mini S&P 500 and Crude Oil contracts, over the most recent two years we observe a significant decrease in ATS–ATS activity and an increase in both ATS–MAN and MAN–MAN; we do not see such movement in Euro FX or the 10 Yr Treasury Note. This may point to an area for future study.

Appendix A contains information on additional products shown in Table 3 as well as five additional agricultural products: lean hogs, KC wheat, soybean oil, soybean meal, and feeder cattle. The equity, energy, rates, and foreign exchange products show similar patterns to those noted above in Figure 1. The E-mini NASDAQ 100 subfigure shows that the shift from ATS–ATS to ATS–MAN took place during the first half of 2017 and levels have remained steady since then. Similarly, for gold and silver, we find a significant movement from ATS–MAN to ATS–ATS at the beginning of our new sample period.

Agricultural products display a number of features that warrant future research. Unlike other products which show a clear decrease in ATS–MAN activity, agricultural products tend to show very little movement in the share of volume associated to this category. For soybean products and corn, this share of volume even appears to be increasing, albeit slightly. Only two agricultural products, Live and Feeder Cattle, show a recent small decrease in this share of volume. Instead, the switch from the MAN–MAN to the ATS–ATS category is perhaps an indication that a relatively high percentage of manual traders have switched to automated systems.

Table 4 builds on Table 3 by adding additional information related to trade type for each counterparty. Since futures trade on either an outright (RO) or spread (SP) basis (outrights referencing only one futures expiration, spreads referencing either multiple expirations or multiple products), we can divide the activity into three groups: RO–RO if both sides of the trade are linked to outrights; RO–SP if one side is an outright and one side is a spread; or SP–SP if both sides are trading a spread. For each product, the shares across the nine possible combinations sum to 100. From this table, we find that spread trading is much more manual. For example, the E-mini S&P 500

product shows 77% of traded volume in outrights is automated compared to 32% of spread volume. The table also shows SP–SP activity, though from a lower base, is becoming more automated. For the main agricultural products, we find an increase in both ATS–ATS and ATS–MAN activity. This differs from energy and the Eurodollar contract, both with active spread markets, where the increase is observed in only ATS–ATS. In Appendix B, we show how these shares have changed during the most recent two years for both RO–RO and SP–SP activity.

All of the analysis above has made use of trade level characteristics to identify automated vs manual and outright vs spread trading. Information about trading activity also allows aggregation by trade volume, distinguishing between large and small volume traders. Table 5 breaks down participant activity into small and large volume traders and shows the percentage of automated and manual trading for each group by product.[4] The percentages included in the table are based on the total trading volume in the product, so numbers sum to 100 percent within a row for each sample period. Apart from two products, the number of small and large traders has decreased relative to the prior sample period. The largest percentage decrease in the number of large traders is found in gold (32% decrease); silver shows a 29% decrease; and crude oil has seen a 25% decrease. The share of ATS activity for large volume traders has increased for most products relative to the prior sample; in contrast, we find the ATS share has fallen for small volume traders across many products. This may signal that small traders have become more manual or that formerly small automated traders have moved into the large trader bucket.

Speed of Trading

Prior versions of this report noted that increases in the level of market automation are often, though not always, paired with increases in the speed of trading activity.

Table 6 shows a breakdown of resting times for executed passive orders; because the values are relative to total (buy and sell side) volume, they add up to approximately 50 percent for each sample period (since every trade has a passive and aggressive side). This table highlights one of the relationships between the level of automation and speed, with a much higher percentage of the shortest-lived orders generated by automated systems. Note that the speeds summarized in this table are a mixture of trader and market speed. The time a passive order rests in the order book is a function both of when the order was placed, as well as when an aggressive order came in and matched against the passive order. Because of this, even manual orders can show up in the fastest time bucket — in this case a, perhaps slow, manual trader posts an order in the book and a fast automated trader responds by trading against it. Even with this balance between trade and market speed, automated trading is much more prevalent in the fastest buckets. In addition, while there has been a general increase in the amount of automated trading occurring within the fastest time buckets, often the amount of manual trading in the fastest bucket has decreased — one possibility is that the fastest manual traders switched to using automated systems, removing themselves from the manual group.

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[4]Trading accounts are classified, on a daily basis, as "large volume traders" if they contribute at least 0.5 percent to total daily volume across all expirations.

Figure 2 provides a similar set of information but now shows the daily time series, for four selected products, over the past two years (see the first set of figures in Appendix C for the remaining nine products). In many cases, changes over the two year period for the four primary contracts have been minimal, indicating only slight shifts in the speed of liquidity provision and removal. The one potential exception to this is the fastest time range $(0-100$ ms), where there have been fairly consistent increases, one sign that markets have indeed gotten progressively faster even in cases where automation levels have remained flat. The fairly small adjustments in market speed appear to extend to the lower volume contracts like physical commodities, contrasting with the fairly significant changes in the level of market automation seen in earlier tables (exceptions to this are noted below).

Table 7 shows a similar breakdown for outright vs. spread trading, with speeds for spread trading (a much less volatile contract type) significantly slower than for outright trades. In general, the difference in speed between outrights and spreads is smallest for contracts where spread trading is more common (e.g. crude oil and Eurodollars). The second and third set of figures in Appendix C show how the shares by speed vary over time for each product for outright and spread volume, respectively. Trends are generally consistent across products.

Table 8 provides a summary of a second speed measure, the speed of inventory turnover for the large volume trader group. The table quantifies what percentage of purchases/sales by these traders are closed within a selected set of times (e.g. one minute, one day). These percentages are always significantly higher for automated traders — for many products, the median holding period for automated trader volume is much less than a day, and is often within a minute of initial execution. In contrast, manual traders have much longer holding periods for most products, pointing to a division between the intraday trading of automated participants versus the interday activity of manual firms. The trends seen here in holding periods are very similar to those in the automated/manual comparisons we made above.

Finally, Figure 3 provides cumulative distribution functions (and distribution variances) for the time between the introduction of a new passive order and its execution, again broken into manual/automated categories. In all cases, automated orders are executed more quickly than manual orders, possibly due to both the speed at which automated orders are canceled/modified and the higher likelihood of automated orders sitting close to the top of the book. Because of this, markets that tend to have higher levels of automation, like the Euro and the E-Mini, are also the fastest markets, as measured by liquidity provision speed. These updated figures, based on data over the past two years, are similar to the summaries constructed for the earlier two year sample. Appendix D collects figures for the remaining nine products.

Conclusion

In summary, after extending the sample for an additional two years (for a total now of six years of trading), we find a continued increased in automation across all commodity futures products, with the largest increases in historically more manual products like agriculture and livestock contracts. Results on the speed of markets are more mixed,

with many markets not significantly "faster" (relative to the measures we consider) than the earlier period. Within our cross-time trends, there do appear to be activity patterns that differentiate automated from manual groups, with automated participants acting more quickly, including more often moving into and out of trading positions within short periods of time. In addition, there are similarly distinct patterns of behavior between spread and outright trading. Outrights, more commonly traded using automation and generally more volatile, are much faster markets and experience less cyclicality of activity through time.

Figure 1: Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)

Notes: For each commodity, total daily volume across all expirations, over the past four years, is divided into trades where the orders on both sides of the trade originated from an automated system (ATS–ATS), where one side originated from an automated system (ATS–MAN), where neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2012 – October 31, 2018.

(a) E-Mini S&P 500

(b) Crude Oil

(c) Euro

(d) 10 Yr Note

Table 1: Manual Vs. Automated Trading By Product Group

Notes: This table summarizes volume by type as a percentage of total volume within the product group (initial percentage in a category) and across the full market (percentage in parentheses). In order to calculated this percentage, each individual transaction is linked to its associated product and then aggregated within the associated product group. Black numbers in the table correspond to the prior update sample period: November 1, 2014 – October 31, 2016. Red numbers correspond to the new sample period: November 1, 2016 – October 31, 2018. Source: CME transaction data.

Product Group Name	Products		Non-Electronic				ATS				Manual			
Low Volume Group	354	278	21.8	(0.1)	65.4	(0.1)	66.1	(0.2)	22.6	(0.0)	12.1	(0.0)	12.0	(0.0)
Agriculture	32	31	4.1	(0.4)	3.2	(0.3)	48.5	(4.3)	55.5	(4.7)	47.5	(4.2)	41.3	(3.5)
Energy	275	236	11.2	(1.8)	6.8	(1.1)	57.5	(9.1)	66.5	(10.8)	31.4	(4.9)	26.7	(4.3)
Equities	25	23	0.9	(0.2)	1.2	(0.2)	71.6	(14.3)	73.7	(12.1)	27.5	(5.5)	25.1	(4.1)
FX	48	49	1.0	(0.1)	1.2	(0.1)	82.7	(5.6)	84.4	(5.4)	16.3	(1.1)	14.4	(0.9)
Interest Rate	12	13	3.4	(1.5)	3.5	(1.7)	66.8	(30.3)	71.2	(34.5)	29.8	(13.5)	25.3	(12.2)
Metals	17	17	4.6	(0.1)	3.0	(0.1)	54.1	(1.6)	67.6	(2.7)	41.3	(1.2)	29.4	(1.2)

Table 2: Manual Vs. Automated Trading By Product Group and Subgroup

Notes: This table summarizes volume as a percentage of the total volume in a product/sub-product pair (initial percentage in a category) and across the full market (percentage in parentheses). Each individual transaction is linked to its associated product, which is then aggregated within the associated product/sub-product category. This table excludes the low volume group of Table 1. Black numbers in the table correspond to the prior update sample period: November 1, 2014 – October 31, 2016. Red numbers correspond to the new sample period: November 1, 2016 – October 31, 2018. Source: CME transaction data.

Product Group and Subgroup Name	Products		Non-Electronic		ATS		Manual	
Agriculture - Commodity Index	5	5	35.7 (0.0)	30.4 (0.0)	22.4 (0.0)	30.6 (0.0)	41.9 (0.0)	39.0 (0.0)
Agriculture - Dairy	6	6	1.7 (0.0)	1.1 (0.0)	14.6 (0.0)	22.9 (0.0)	83.7 (0.0)	75.9 (0.0)
Agriculture - Grain and Oilseed	13	12	4.1 (0.3)	3.4 (0.3)	49.0 (3.9)	55.2 (4.1)	46.9 (3.8)	41.3 (3.1)
Agriculture - Livestock	3	3	2.5 (0.0)	0.4 (0.0)	45.8 (0.4)	59.5 (0.5)	51.8 (0.4)	40.1 (0.4)
Agriculture - Lumber and Pulp	1	1	1.4 (0.0)	1.0 (0.0)	20.4 (0.0)	25.5 (0.0)	78.2 (0.0)	73.5 (0.0)
Energy - Biofuels	5	5	85.3 (0.0)	90.8 (0.0)	2.4 (0.0)	1.2 (0.0)	12.2 (0.0)	8.0 (0.0)
Energy - Coal	8	6	100.0 (0.1)	99.9 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Energy - Crude Oil	21	22	3.5 (0.3)	2.5 (0.2)	63.0 (5.5)	70.4 (6.8)	33.6 (2.9)	27.1 (2.6)
Energy - Electricity	59	36	100.0 (0.5)	100.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Energy - Natural Gas	40	36	13.3 (0.5)	8.1 (0.3)	56.8 (2.0)	65.7 (2.2)	29.9 (1.0)	26.1 (0.9)
Energy - Refined Products	122	111	12.2 (0.4)	9.8 (0.3)	54.6 (1.6)	61.5 (1.7)	33.2 (1.0)	28.7 (0.8)
Equities - International Index	4	4	0.2 (0.0)	0.3 (0.0)	76.2 (0.5)	80.1 (0.3)	23.6 (0.1)	19.6 (0.1)
Equities - Select Sector Index	9	9	42.2 (0.0)	39.4 (0.0)	45.3 (0.0)	46.3 (0.0)	12.4 (0.0)	14.2 (0.0)
Equities - US Index	12	10	0.8 (0.2)	1.0 (0.2)	71.5 (13.8)	73.7 (11.8)	27.7 (5.3)	25.3 (4.0)
FX - E Micros	8	7	0.0 (0.0)	0.0 (0.0)	69.3 (0.1)	70.9 (0.1)	30.7 (0.1)	29.1 (0.1)
FX - Emerging Markets	16	17	5.6 (0.0)	5.4 (0.0)	76.2 (0.4)	78.6 (0.4)	18.2 (0.1)	16.0 (0.1)
FX - G10	24	25	0.7 (0.0)	0.8 (0.0)	83.7 (5.1)	85.4 (4.8)	15.6 (1.0)	13.8 (0.8)
Interest Rate - Deliverable Swaps	4	4	10.0 (0.0)	10.0 (0.0)	47.5 (0.0)	48.0 (0.0)	42.5 (0.0)	42.0 (0.0)
Interest Rate - Stirs	3	3	2.1 (0.5)	2.7 (0.6)	65.1 (13.8)	69.0 (15.1)	32.8 (7.0)	28.4 (6.2)
Interest Rate - US Treasury	5	6	4.5 (1.1)	4.2 (1.1)	68.4 (16.4)	73.1 (19.4)	27.1 (6.5)	22.7 (6.0)
Metals - Base	4	4	2.2 (0.0)	1.4 (0.0)	56.9 (0.4)	70.0 (0.6)	40.9 (0.3)	28.7 (0.3)
Metals - Precious	8	8	5.0 (0.1)	3.3 (0.1)	53.5 (1.3)	67.1 (2.1)	41.5 (1.0)	29.6 (0.9)

Table 3: Manual Vs. Automated Trading Most Active Products

Product Group and Subgroup	Futures Product Name	Total Volume	ATS	MAN	ATS–ATS	ATS–MAN	MAN–MAN
Agriculture - Grain and Oilseed	Corn	168 / 186	45.7 / 52.5	49.7 / 43.9	23.1 / 29.0	45.1 / 46.9	27.1 / 20.4
Agriculture - Grain and Oilseed	Soybean	115 / 114	47.9 / 53.3	46.9 / 42.0	25.1 / 30.0	45.6 / 46.5	24.1 / 18.7
Agriculture - Grain and Oilseed	Wheat	62 / 71	53.1 / 62.2	45.4 / 36.7	29.3 / 39.2	47.5 / 45.9	21.6 / 13.7
Agriculture - Livestock	Live Cattle	26 / 32	46.1 / 60.4	51.5 / 39.4	22.1 / 37.0	47.9 / 46.7	27.5 / 16.0
Energy - Crude Oil	Crude Oil	454 / 618	60.4 / 69.4	36.5 / 28.5	38.1 / 49.9	44.5 / 39.0	14.2 / 9.0
Energy - Natural Gas	Natural Gas (Henry Hub)	175 / 219	63.3 / 69.9	33.1 / 26.9	42.5 / 50.9	41.6 / 38.0	12.3 / 7.9
Energy - Refined Products	RBOB Gasoline Physical	84 / 99	55.3 / 61.2	37.0 / 32.7	33.5 / 40.7	43.6 / 40.9	15.2 / 12.2
Equities - US Index	E-mini S&P 500	891 / 795	70.3 / 72.9	29.6 / 26.5	50.6 / 55.3	39.3 / 35.1	9.9 / 8.9
Equities - US Index	E-mini NASDAQ 100	134 / 176	77.1 / 74.0	22.2 / 25.4	60.1 / 54.4	33.9 / 39.1	5.2 / 5.8
Equities - US Index	E-mini Dow ($5)	82 / 88	80.2 / 81.2	19.7 / 18.7	64.6 / 66.1	31.1 / 30.1	4.1 / 3.6
FX - G10	Euro	115 / 125	80.3 / 82.0	19.1 / 17.2	66.3 / 69.4	28.0 / 25.1	5.1 / 4.6
FX - G10	Japanese Yen	74 / 80	87.1 / 88.6	12.3 / 10.9	77.7 / 80.0	18.8 / 17.1	2.9 / 2.3
FX - G10	British Pound	52 / 63	84.6 / 86.2	14.8 / 13.5	74.1 / 76.1	21.0 / 20.1	4.3 / 3.4
Interest Rate - Stirs	Eurodollar	1,193 / 1,421	66.3 / 70.3	31.7 / 27.0	44.0 / 49.6	44.5 / 41.3	9.4 / 6.3
Interest Rate - US Treasury	10 Yr Note	661 / 821	67.9 / 72.7	28.6 / 24.2	48.0 / 54.9	39.7 / 35.5	8.7 / 6.4
Interest Rate - US Treasury	5 Yr Note	378 / 500	70.2 / 74.0	24.4 / 21.1	53.2 / 58.7	34.0 / 30.6	7.4 / 5.8
Metals - Base	Copper	97 / 61	53.2 / 70.2	41.3 / 28.7	31.7 / 52.2	42.9 / 36.0	19.8 / 10.7
Metals - Precious	Gold	162 / 153	65.0 / 67.6	28.5 / 28.8	46.1 / 50.2	37.8 / 34.8	9.6 / 11.4
Metals - Precious	Silver	31 / 47	54.1 / 67.1	42.6 / 30.3	36.0 / 51.5	36.2 / 31.2	24.5 / 14.7

Notes: The table summarizes participant activity broken down by manual/automated type for the top three products by volume in each product group. Total volume is reported in millions of contracts; all other numbers represent shares of total volume. The first few columns shows the share of total volume linked to automated (ATS) and manual (MAN) trading. The remaining columns shows the share of volume when both sides of the trade are automated (ATS–ATS), when only one side is automated (ATS–MAN), and finally when neither side is automated (MAN–MAN). Black numbers correspond to the original sample period: November 1, 2014 – October 31, 2016. Red numbers correspond to the new sample period: November 1, 2016 – October 31, 2018. Source: CME transaction data.

Table 4: Volume Shares By Product and Trade Type

Notes: This table provides a further breakdown for the most active products found in Table 3. These thirteen products will be the primary focus for the rest of the study. For each product, percentages of total volume in the product over the sample period are grouped by automated or manual counterparties and by whether the trade matches regular outrights (RO) or spreads (SP). Cases where an outright trade is matched with a spread trade are possible due to implied spread functionality provided by the exchange (when this functionality does not exist, the cells are blank). Note that this chart restricts attention to just electronic trading. Black numbers correspond to the original sample period: November 1, 2014 – October 31, 2016. Red numbers correspond to the new sample period: November 1, 2016 – October 31, 2018. Source: CME transaction data.

Values shown as black (red).

Futures Product Name	ATS–ATS			ATS–MAN			MAN–MAN		
	RO–RO	RO–SP	SP–SP	RO–RO	RO–SP	SP–SP	RO–RO	RO–SP	SP–SP
E-mini S&P 500	50.3 (54.5)	- (-)	0.4 (0.8)	37.1 (31.6)	- (-)	2.2 (3.5)	6.0 (5.2)	- (-)	3.8 (3.7)
E-mini NASDAQ 100	59.8 (54.0)	- (-)	0.3 (0.3)	32.3 (37.9)	- (-)	1.6 (1.2)	3.0 (4.5)	- (-)	2.2 (1.3)
Crude Oil	17.1 (27.1)	3.5 (3.0)	17.6 (19.8)	19.1 (16.1)	4.1 (2.6)	21.3 (20.4)	4.9 (2.8)	1.4 (0.6)	7.8 (5.6)
Natural Gas (Henry Hub)	15.4 (17.6)	5.7 (5.7)	21.5 (27.6)	10.4 (9.6)	5.6 (4.0)	25.6 (24.4)	2.5 (2.1)	1.4 (0.6)	8.4 (5.2)
Eurodollar	17.1 (18.9)	5.7 (5.2)	21.2 (25.5)	17.6 (16.7)	6.1 (4.7)	20.8 (19.9)	4.8 (3.2)	1.4 (0.9)	3.1 (2.2)
10 Yr Note	45.2 (50.7)	0.5 (0.7)	2.2 (3.5)	32.9 (27.6)	0.5 (0.5)	6.3 (7.3)	5.1 (3.3)	0.1 (0.1)	3.5 (3.0)
5 Yr Note	49.1 (52.6)	0.9 (1.1)	3.2 (5.0)	24.2 (19.5)	0.7 (0.7)	9.0 (10.4)	2.2 (1.3)	0.1 (0.1)	5.1 (4.5)
Euro	65.9 (67.8)	- (0.4)	0.4 (1.2)	24.7 (19.4)	- (0.6)	3.3 (5.1)	1.8 (1.0)	- (0.2)	3.4 (3.5)
Japanese Yen	77.2 (78.9)	- (0.2)	0.5 (0.9)	16.5 (13.7)	- (0.3)	2.3 (3.2)	0.6 (0.4)	- (0.1)	2.3 (1.8)
Corn	15.4 (17.7)	2.1 (2.3)	5.7 (9.0)	18.7 (19.1)	6.0 (5.3)	20.3 (22.5)	6.5 (5.2)	4.2 (2.8)	16.4 (12.4)
Soybean	14.5 (17.2)	3.8 (3.6)	6.7 (9.2)	18.3 (17.9)	8.1 (6.5)	19.3 (22.1)	5.9 (4.5)	4.4 (2.9)	13.7 (11.3)
Live Cattle	9.2 (12.9)	5.4 (7.0)	7.5 (17.1)	16.4 (16.0)	12.8 (10.6)	18.7 (20.1)	8.1 (5.6)	8.4 (4.1)	11.0 (6.3)
Gold	30.5 (49.3)	0.5 (0.5)	0.7 (0.5)	34.6 (28.7)	2.3 (1.6)	5.9 (4.5)	7.8 (3.6)	1.8 (1.0)	10.1 (6.9)
Silver	35.6 (50.5)	0.1 (0.3)	0.2 (0.6)	29.1 (23.8)	2.1 (1.4)	5.1 (6.0)	4.7 (2.6)	1.7 (0.8)	18.1 (11.3)

Table 5: Volume Shares By Product and Trader Group

Note: In each cell the first (black) number corresponds to the new sample period and the second (red) number corresponds to the original sample period.

Futures Product Name	N	Small Volume Trader — ATS	Small Volume Trader — MAN	N	Large Volume Trader — ATS	Large Volume Trader — MAN
E-mini S&P 500	143,363 / 115,773	19.5 / 20.2	25.5 / 22.7	423 / 424	50.8 / 52.7	4.0 / 3.8
E-mini NASDAQ 100	59,030 / 58,910	16.8 / 17.5	17.2 / 19.5	446 / 410	60.3 / 56.5	5.0 / 5.8
Crude Oil	91,325 / 72,028	18.3 / 15.7	27.7 / 21.9	388 / 293	42.1 / 53.8	8.8 / 6.6
Natural Gas (Henry Hub)	35,136 / 31,291	17.8 / 17.0	21.7 / 19.1	565 / 459	45.6 / 52.9	11.4 / 7.8
Eurodollar	20,423 / 18,165	16.2 / 14.9	25.2 / 20.2	575 / 570	50.0 / 55.4	6.4 / 6.7
10 Yr Note	50,232 / 45,015	21.3 / 20.3	23.7 / 19.8	702 / 622	46.5 / 52.4	4.9 / 4.3
5 Yr Note	24,741 / 24,067	22.3 / 20.6	18.0 / 14.8	1,102 / 965	47.9 / 53.4	6.4 / 6.3
Euro	43,434 / 36,561	15.7 / 15.8	14.5 / 12.5	467 / 454	64.6 / 66.2	4.6 / 4.7
Japanese Yen	26,595 / 22,512	15.2 / 15.6	8.9 / 7.8	441 / 372	71.9 / 73.0	3.4 / 3.0
Corn	72,535 / 65,252	20.8 / 20.5	27.8 / 25.7	731 / 713	24.9 / 31.9	21.8 / 18.2
Soybean	61,960 / 53,262	22.1 / 22.1	33.0 / 29.2	772 / 773	25.8 / 31.1	13.9 / 12.8
Live Cattle	34,719 / 32,227	15.1 / 15.3	36.0 / 29.6	918 / 741	30.9 / 45.0	15.5 / 9.7
Gold	56,301 / 49,405	19.4 / 17.3	26.4 / 19.3	626 / 428	33.7 / 50.4	14.8 / 9.5
Silver	23,186 / 21,722	18.1 / 17.6	20.5 / 15.5	709 / 505	35.9 / 49.5	22.1 / 14.8

Notes: This table summarizes trading activity in the thirteen selected contracts, broken down by participant size and the use of automation. In order to create the size breakdown, trading accounts are classified, on a daily basis, as "large volume trader" if they contribute at least 0.5 percent to total daily volume across all expirations. All accounts not meeting this criteria are grouped into the "small trader" category. Individual percentages in the table represent the breakdown between automated and manual volume for the trader group as a percentage of total product volume. The table also includes the aggregate number of unique accounts observed in each category over the full sample period (N) — note it is possible for an account to be included in both small and large totals, since the classification is done on a product-day basis rather than strictly on a product basis. Black numbers correspond to the original sample period: November 1, 2014 – October 31, 2016. Red numbers correspond to the new sample period: November 1, 2016 – October 31, 2018. Source: CME transaction data.

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Table 6: Time Between Order Placement and Execution for Liquidity Providers

Notes: This table breaks down trading volume by the time between the initial placement (or most recent modification) of the order representing the passive side of the trade and the trade itself. This volume is then scaled by the total two-sided volume for the given product. Note that a small subset of trades for active intra-commodity spreads have both sides marked as non-aggressive, so values in the rows may sum to a number greater than 50 percent (e.g., Eurodollar row percentages sum to 54.5 percent for the early period). Black numbers correspond to the original sample period: November 1, 2014 – October 31, 2016. Red numbers correspond to the new sample period: November 1, 2016 – October 31, 2018. Source: CME transaction data.

Each cell shows two values: black (original period: Nov 1, 2014 – Oct 31, 2016) / red (new period: Nov 1, 2016 – Oct 31, 2018).

Futures Product Name	0 – 100 ms ATS	0 – 100 ms MAN	100 ms – 500 ms ATS	100 ms – 500 ms MAN	500 ms – 1 sec ATS	500 ms – 1 sec MAN	1 sec – 10 sec ATS	1 sec – 10 sec MAN	10 sec – 1 min ATS	10 sec – 1 min MAN	Remaining Elec Volume
E-mini S&P 500	9.6 / 10.2	0.6 / 0.5	4.1 / 3.9	0.5 / 0.3	2.8 / 2.6	0.5 / 0.3	10.7 / 10.2	3.1 / 2.2	5.3 / 5.9	2.8 / 2.3	9.9 / 11.2
E-mini NASDAQ 100	11.3 / 12.9	0.9 / 1.0	6.7 / 6.7	0.6 / 0.7	3.8 / 3.4	0.5 / 0.7	10.8 / 8.8	2.8 / 3.4	4.0 / 3.5	2.1 / 2.3	6.2 / 6.1
Crude Oil	5.6 / 7.9	1.1 / 0.9	2.9 / 2.9	0.6 / 0.3	1.8 / 1.8	0.4 / 0.2	7.5 / 7.8	2.6 / 1.7	5.2 / 5.4	3.0 / 2.1	20.2 / 19.5
Natural Gas (Henry Hub)	4.4 / 5.7	1.1 / 1.2	1.5 / 1.6	0.3 / 0.3	1.0 / 1.0	0.2 / 0.2	6.9 / 6.7	1.8 / 1.4	7.2 / 6.9	2.9 / 2.1	24.2 / 23.9
Eurodollar	3.2 / 5.1	0.9 / 1.6	2.3 / 2.0	0.6 / 0.4	1.3 / 1.1	0.3 / 0.2	6.0 / 5.6	1.5 / 1.0	6.7 / 6.6	2.6 / 1.8	27.0 / 26.1
10 Yr Note	6.5 / 8.0	0.5 / 0.3	2.1 / 1.8	0.3 / 0.1	1.4 / 1.2	0.2 / 0.1	7.8 / 7.0	1.9 / 1.1	7.9 / 7.6	2.8 / 1.9	17.0 / 19.5
5 Yr Note	6.6 / 7.7	0.7 / 0.5	2.3 / 2.0	0.3 / 0.2	1.4 / 1.2	0.2 / 0.1	7.7 / 6.8	1.5 / 1.0	8.0 / 7.7	2.2 / 1.6	16.9 / 19.3
Euro	12.4 / 14.0	0.9 / 0.8	5.1 / 4.4	0.4 / 0.3	2.7 / 2.5	0.3 / 0.2	10.6 / 10.2	1.8 / 1.5	4.9 / 4.7	1.6 / 1.3	9.1 / 9.9
Japanese Yen	12.6 / 14.5	0.7 / 0.6	5.2 / 5.0	0.2 / 0.2	2.7 / 2.6	0.2 / 0.2	11.6 / 11.3	1.0 / 1.0	6.5 / 5.8	1.0 / 0.8	8.2 / 7.8
Corn	2.3 / 2.6	0.5 / 0.4	0.9 / 0.8	0.2 / 0.2	0.7 / 0.6	0.2 / 0.1	4.2 / 3.9	1.8 / 1.4	4.8 / 4.8	3.3 / 2.6	32.4 / 33.7
Soybean	2.8 / 3.2	0.8 / 0.7	1.3 / 1.2	0.4 / 0.3	1.0 / 0.9	0.3 / 0.2	5.8 / 5.4	2.7 / 2.0	5.1 / 5.0	3.7 / 2.9	28.1 / 29.4
Live Cattle	2.8 / 5.0	2.0 / 1.7	1.3 / 2.0	0.6 / 0.5	1.1 / 1.5	0.5 / 0.4	6.8 / 8.8	4.3 / 3.2	6.8 / 8.1	6.0 / 4.2	24.4 / 20.0
Gold	4.8 / 8.2	1.3 / 0.5	3.3 / 3.7	0.6 / 0.3	2.1 / 2.3	0.5 / 0.2	8.8 / 10.8	3.1 / 1.9	4.5 / 5.7	2.8 / 1.9	16.7 / 13.4
Silver	5.0 / 7.9	0.9 / 0.4	2.2 / 2.2	0.3 / 0.1	1.5 / 1.5	0.3 / 0.1	8.2 / 8.3	2.1 / 1.2	6.3 / 7.5	3.0 / 2.0	19.7 / 18.1

Table 7: Time Between Order Placement and Execution for Liquidity Providers: Outright (Black) Vs. Spread (Blue)

Futures Product Name	0 – 100 ms		100 ms – 500 ms		500 ms – 1 sec		1 sec – 10 sec		10 sec – 1 min		Remaining
	ATS	MAN	ATS	MAN	ATS	MAN	ATS	MAN	ATS	MAN	Elec Volume
E-mini S&P 500	11.1 (0.3)	0.5 (0.8)	4.3 (0.2)	0.4 (0.2)	2.8 (0.1)	0.3 (0.0)	11.0 (0.7)	2.4 (0.7)	6.2 (1.6)	2.3 (2.1)	8.3 (43.4)
E-mini NASDAQ 100	13.2 (0.9)	1.0 (1.5)	6.9 (0.2)	0.7 (0.3)	3.5 (0.1)	0.7 (0.1)	9.0 (1.7)	3.5 (1.1)	3.5 (3.4)	2.3 (3.0)	5.2 (37.6)
Crude Oil	11.7 (4.2)	0.6 (1.3)	4.7 (1.2)	0.4 (0.2)	2.8 (0.7)	0.4 (0.1)	11.2 (4.4)	2.5 (1.0)	5.2 (5.7)	2.3 (2.0)	7.7 (31.3)
Natural Gas (Henry Hub)	8.6 (4.1)	1.1 (1.2)	2.6 (1.0)	0.4 (0.2)	1.7 (0.6)	0.3 (0.1)	10.6 (4.5)	2.1 (1.0)	8.0 (6.3)	2.4 (2.0)	10.7 (31.3)
Eurodollar	4.8 (5.3)	1.0 (2.0)	2.2 (1.8)	0.3 (0.4)	1.4 (1.0)	0.1 (0.2)	6.2 (5.1)	1.1 (0.8)	6.8 (6.5)	2.1 (1.6)	23.4 (28.3)
10 Yr Note	9.2 (0.9)	0.3 (0.5)	2.1 (0.4)	0.1 (0.1)	1.4 (0.3)	0.1 (0.1)	7.8 (2.2)	1.1 (1.3)	8.3 (3.9)	1.9 (1.7)	16.1 (39.3)
5 Yr Note	9.5 (1.0)	0.5 (0.3)	2.4 (0.5)	0.2 (0.1)	1.5 (0.3)	0.1 (0.1)	8.0 (2.4)	1.0 (1.0)	8.7 (4.0)	1.6 (1.6)	13.6 (40.6)
Euro	15.6 (0.4)	0.8 (0.3)	4.9 (0.1)	0.3 (0.0)	2.7 (0.1)	0.2 (0.0)	11.3 (1.1)	1.6 (0.7)	4.9 (2.6)	1.3 (1.3)	5.8 (44.7)
Japanese Yen	15.4 (0.6)	0.6 (0.4)	5.4 (0.2)	0.2 (0.0)	2.8 (0.2)	0.2 (0.0)	12.0 (1.0)	1.0 (0.7)	6.0 (2.5)	0.8 (0.7)	5.2 (45.6)
Corn	4.6 (0.7)	0.5 (0.4)	1.4 (0.3)	0.2 (0.1)	1.0 (0.2)	0.2 (0.1)	6.5 (1.3)	1.9 (0.8)	7.5 (2.2)	3.4 (1.9)	20.3 (47.3)
Soybean	5.3 (1.1)	0.9 (0.6)	2.0 (0.3)	0.3 (0.1)	1.5 (0.3)	0.3 (0.1)	8.8 (2.0)	3.0 (1.0)	7.1 (3.0)	3.7 (2.0)	13.0 (46.2)
Live Cattle	5.6 (4.5)	1.7 (1.7)	2.5 (1.6)	0.6 (0.4)	1.9 (1.2)	0.5 (0.4)	10.2 (7.6)	3.8 (2.7)	7.0 (9.1)	4.3 (4.2)	12.7 (26.0)
Gold	9.6 (0.1)	0.6 (0.2)	4.3 (0.1)	0.3 (0.1)	2.7 (0.0)	0.3 (0.0)	12.5 (0.3)	2.1 (2.7)	6.6 (0.7)	2.0 (1.1)	7.3 (50.5)
Silver	9.9 (0.1)	0.4 (0.4)	2.8 (0.0)	0.2 (0.1)	1.8 (0.0)	0.1 (0.1)	10.3 (0.5)	1.2 (1.1)	9.0 (1.1)	1.8 (2.6)	11.3 (46.0)

Notes: This table breaks down trading volume by the time between the initial placement (or most recent modification) of the order representing the passive side of the trade and the trade itself. This volume is then scaled by the total two-sided volume for the given product. Note that a small subset of trades for active intra-commodity spreads have both sides marked as non-aggressive, so values in the rows may sum to a number greater than 50 percent. Black (blue) numbers correspond to outright (spread) trading in the updated period. Source: CME transaction data, November 1, 2016 – October 31, 2018.

Table 8: Non-Directional Trading of Large Volume Traders

Notes: This table summarizes the level of intraday trading activity of "large traders", using the classification described in Table 5. It calculates the amount of non-directional trading, for a selected time range, as a percentage of group trade volume during that range. For example, for the full day summary, all buy and sell activity within a given trading day is aggregated by contract expiration and account. T The level of non-directional trading is then defined as the minimum of the aggregated buy and sell quantities (the quantity which would be netted off at the end of the day). These levels are then summed across all expirations and accounts and scaled by total trading volume for the day. The same procedure is used for the smaller time intervals of 1, 3 and 5 minutes. Black numbers correspond to the original sample period: November 1, 2014 – October 31, 2016. Red numbers correspond to the new sample period: November 1, 2016 – October 31, 2018. Source: CME transaction data.

Total Large Volume Trader VM (%)

Each cell shows: black (original sample) / red (new sample).

Futures Product Name	Full Day ATS	Full Day MAN	1 Min ATS	1 Min MAN	3 Min ATS	3 Min MAN	5 Min ATS	5 Min MAN
E-mini S&P 500	90.8 / 90.8	4.9 / 3.5	66.8 / 65.4	2.3 / 1.3	77.0 / 75.3	2.9 / 1.6	80.4 / 78.8	3.1 / 1.8
E-mini NASDAQ 100	89.1 / 89.0	4.6 / 7.7	63.0 / 68.5	1.9 / 4.8	73.1 / 76.8	2.5 / 5.7	76.7 / 79.6	2.7 / 6.0
Crude Oil	78.7 / 84.9	12.3 / 7.1	47.5 / 52.3	3.6 / 1.4	56.0 / 60.5	5.1 / 2.1	59.6 / 64.0	5.8 / 2.4
Natural Gas (Henry Hub)	69.6 / 76.5	9.9 / 4.6	32.3 / 34.6	1.4 / 0.6	41.3 / 43.5	2.2 / 0.9	45.4 / 47.8	2.7 / 1.1
Eurodollar	78.2 / 78.6	5.4 / 4.0	20.6 / 18.9	0.5 / 0.3	28.6 / 26.3	0.8 / 0.4	33.3 / 30.8	1.0 / 0.5
10 Yr Note	86.5 / 88.4	4.9 / 3.0	41.0 / 42.9	0.7 / 0.2	55.4 / 55.7	1.2 / 0.4	61.8 / 61.7	1.5 / 0.5
5 Yr Note	79.8 / 80.6	3.3 / 2.5	30.0 / 29.9	0.4 / 0.3	43.5 / 41.8	0.6 / 0.4	49.7 / 47.8	0.7 / 0.5
Euro	89.3 / 89.6	2.4 / 2.3	47.5 / 48.3	0.4 / 0.3	59.3 / 59.4	0.6 / 0.4	64.2 / 63.9	0.7 / 0.5
Japanese Yen	89.7 / 91.3	1.2 / 1.0	41.3 / 42.9	0.1 / 0.1	53.7 / 55.1	0.3 / 0.2	59.2 / 60.4	0.4 / 0.2
Corn	46.3 / 53.8	31.0 / 22.1	19.2 / 20.5	5.2 / 3.4	25.5 / 27.2	8.1 / 5.5	28.5 / 30.4	9.7 / 6.6
Soybean	60.3 / 62.5	21.7 / 16.5	29.0 / 26.8	3.4 / 2.6	37.4 / 34.7	5.1 / 3.9	41.1 / 38.3	6.1 / 4.7
Gold	64.8 / 81.9	18.1 / 9.9	34.2 / 52.9	2.3 / 1.7	42.9 / 62.5	3.8 / 2.5	46.5 / 66.0	4.7 / 2.9
Silver	57.6 / 73.7	22.8 / 13.9	28.3 / 41.4	2.7 / 1.7	37.5 / 52.2	4.6 / 3.0	41.2 / 56.5	5.7 / 3.7

Notes: This figure summarizes the speed of passive order execution across four futures products. The difference between order entry (or most recent modification) and trade execution for the passive side of each trade is calculated; these differences are then average across all transactions in a trading day and grouped into five ranges. These five ranges are: (1) 0 – 100 ms (Blue), (2) 101 ms – 500 ms (Red), (3) 501 ms – 1 s (Green), (4) 1.001 s – 10 s (Purple), and (5) 10.001 s – 60 s (Orange), and are charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) E-Mini S&P 500

(b) Crude Oil

(c) Euro

(d) 10 Yr Note

Figure 3: Liquidity Provision Time Between Order Placement and Execution for ATS (Blue) and Manual (Red)

Notes: This figure summarizes the cumulative volume of passive execution across four futures contracts. For each transaction the time between order entry (or most recent modification) and execution was computed. These differences were rounded to the nearest 10 ms and ordered by increasing time. From this ordered set, the cumulative volume as a percent of total in both the ATS or MAN categories is charted. The bands show 1 standard deviation above and below the average across the sample period. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) E-Mini S&P 500

(b) Crude Oil

(c) Euro

(d) 10 Yr Note
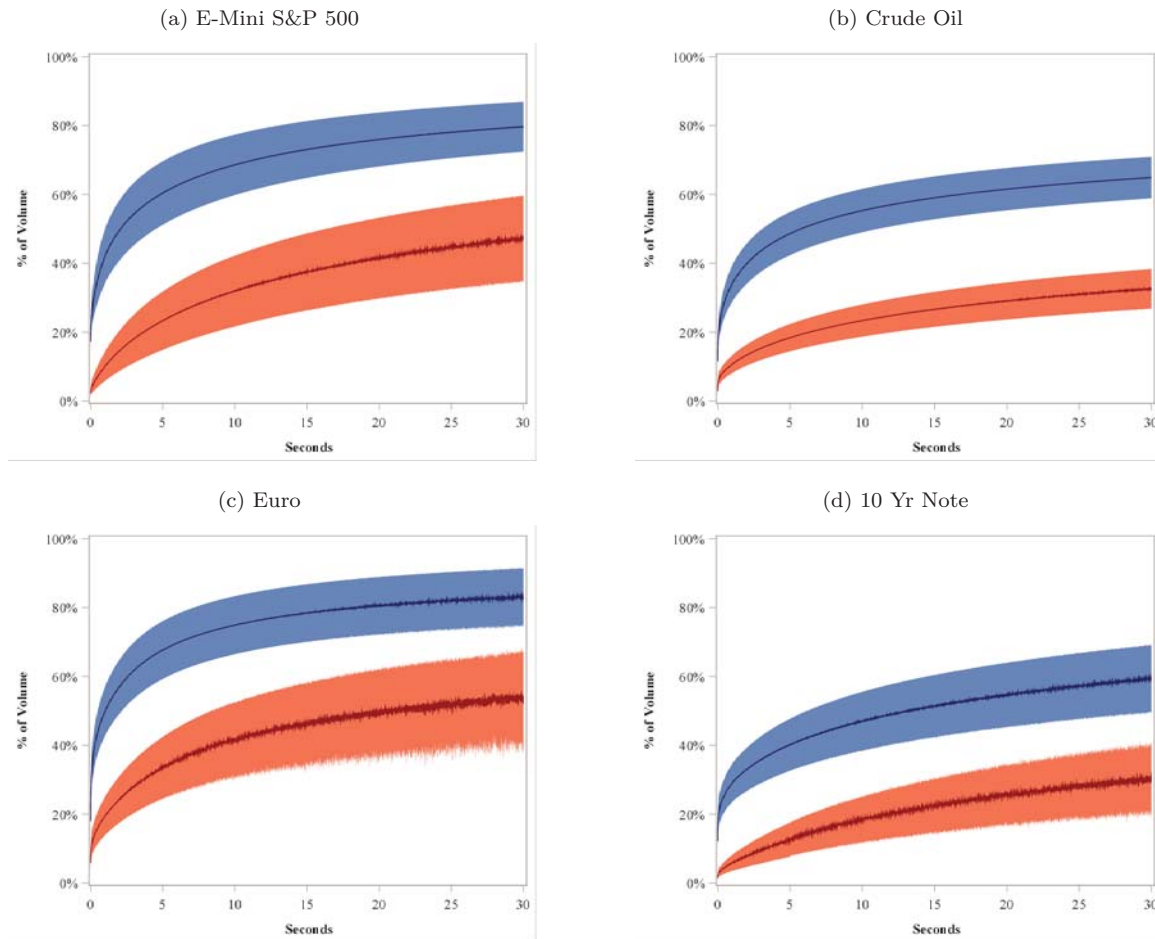
Appendix A: Daily Volume Percentages for ATS–ATS, ATS–MAN, and MAN–MAN

Figure 4: Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)
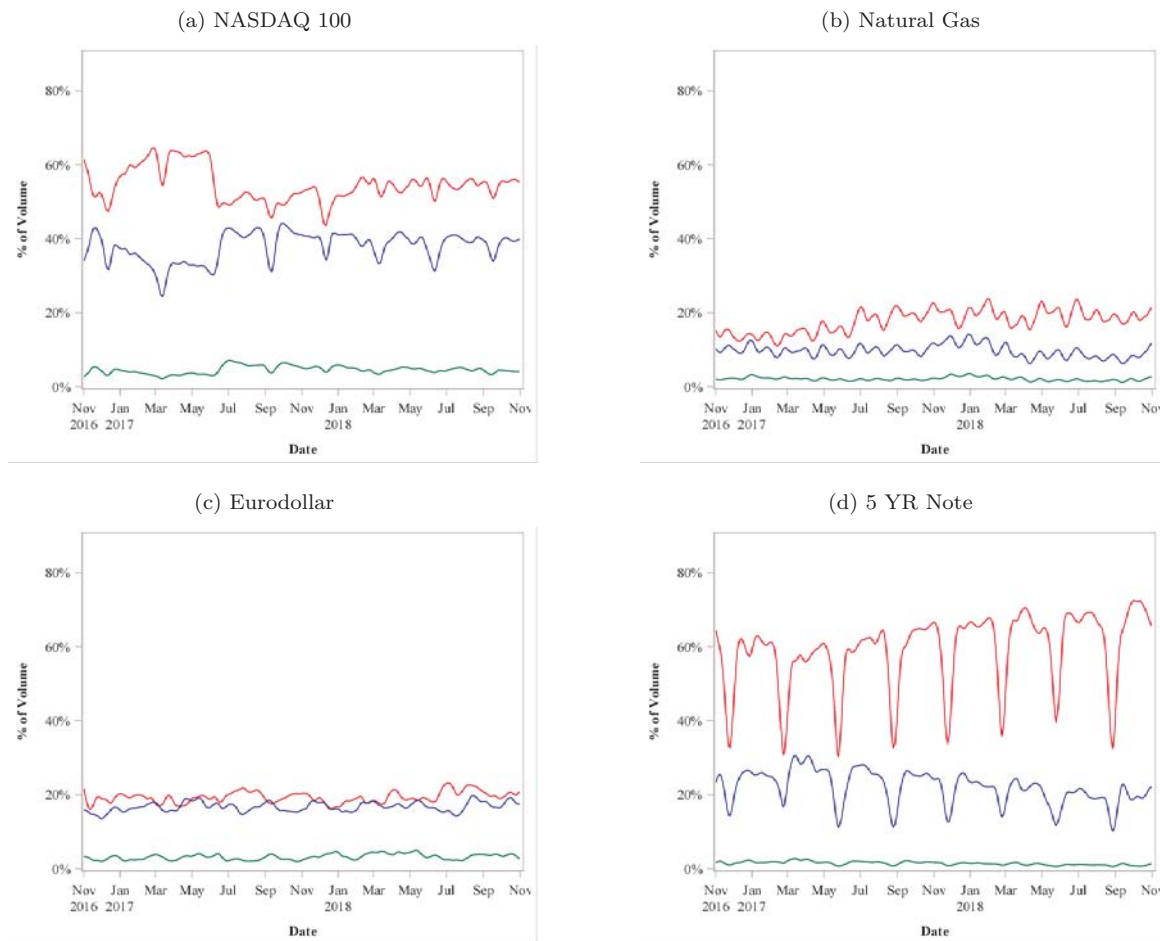
Notes: For each commodity, total daily volume, over the past four years, across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2012 – October 31, 2018.

(a) NASDAQ 100

(b) Natural Gas

(c) Eurodollar

(d) 5 YR Note
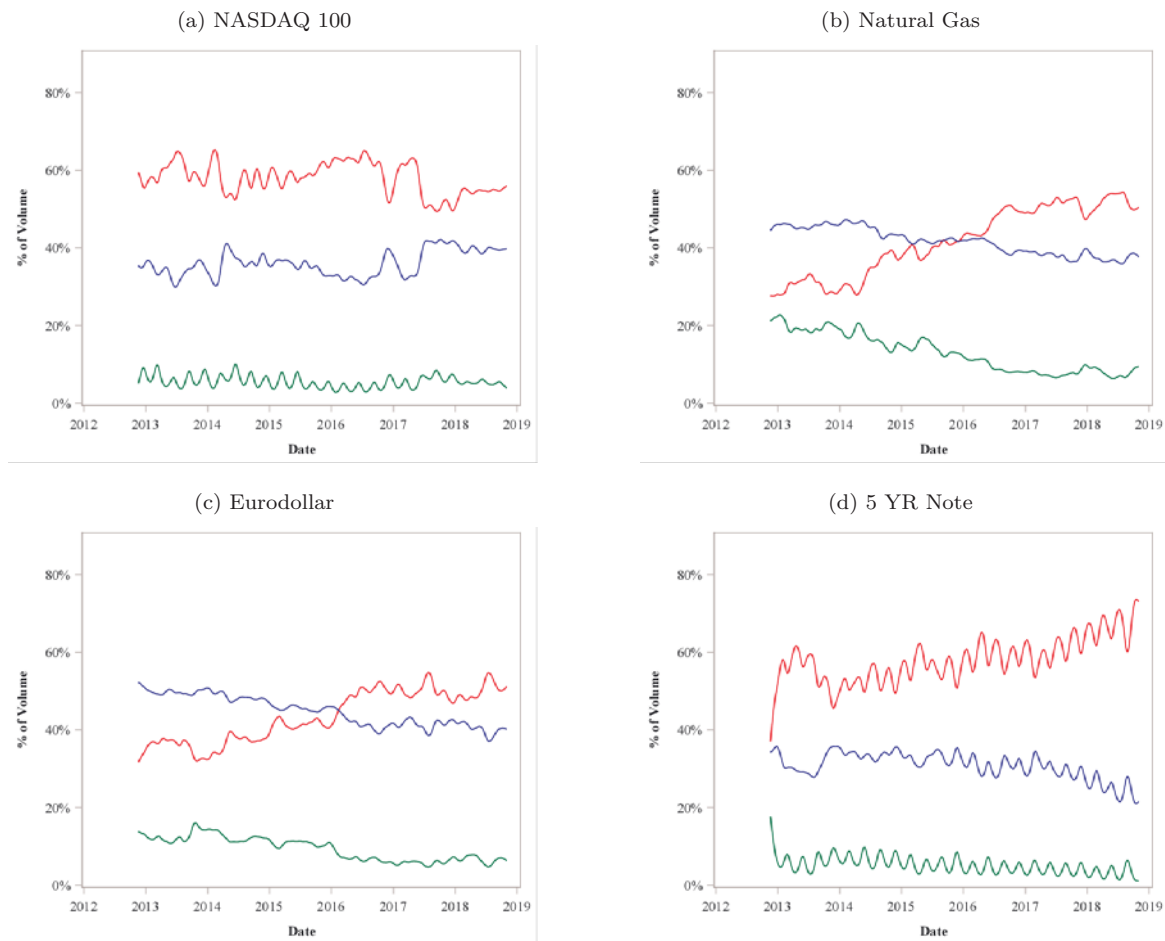
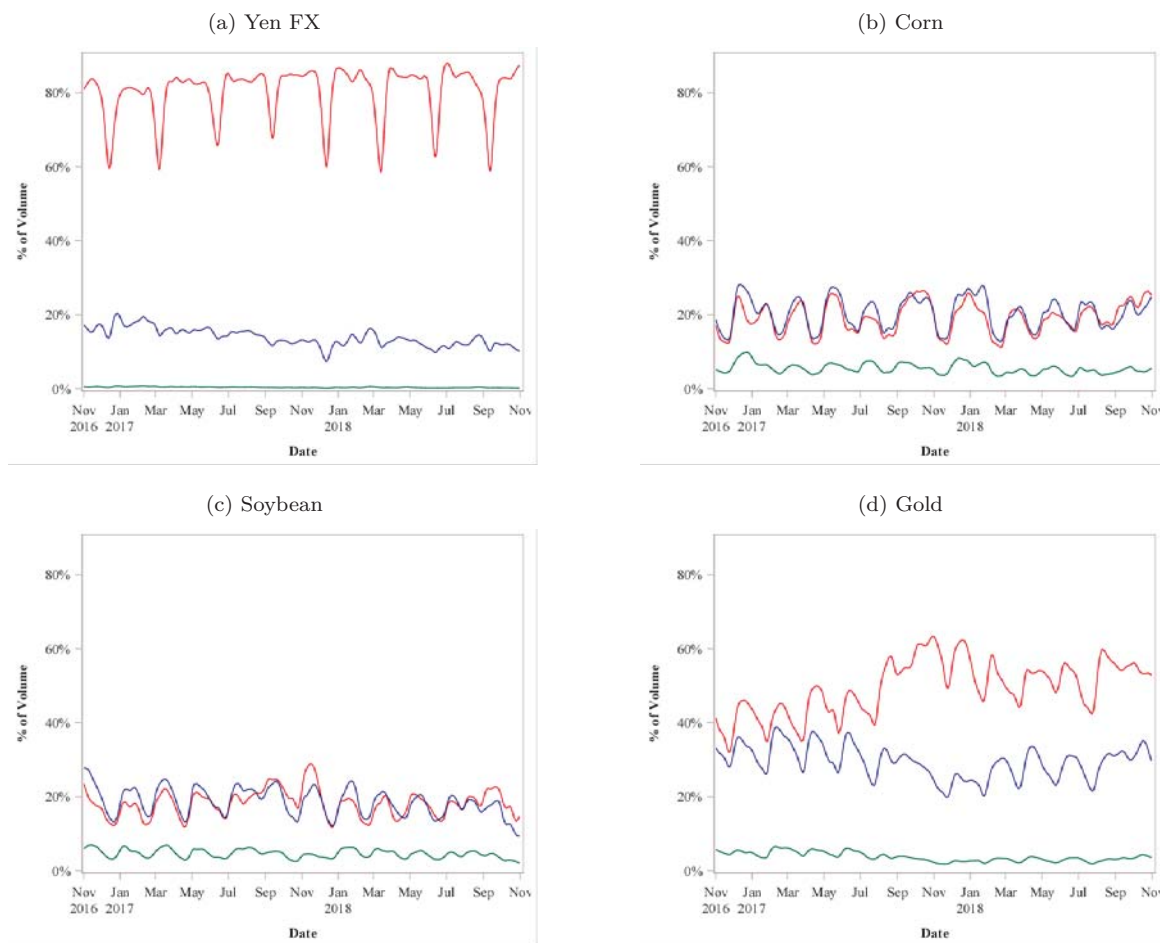Figure 5: Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)

Notes: For each commodity, total daily volume, over the past four years, across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2012 – October 31, 2018.

(a) Yen FX

(b) Corn

(c) Soybean

(d) Gold

Appendix A: Cont.

Figure 6: Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)

Notes: For each commodity, total daily volume, over the past four years, across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2012 – October 31, 2018.
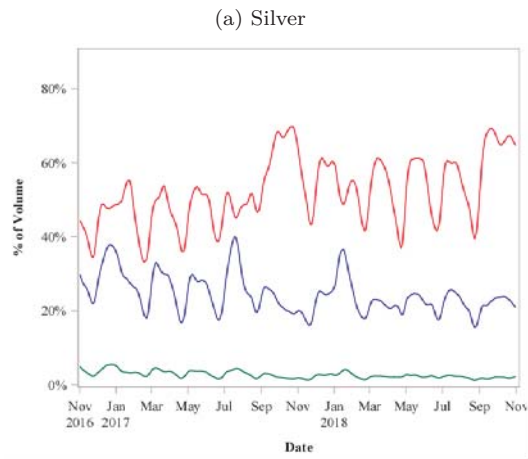
(a) Silver

(b) Wheat

(c) Soybean Oil

(d) Soybean Meal

Figure 7: Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)

Notes: For each commodity, total daily volume, over the past four years, across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2012 – October 31, 2018.

(a) Live Cattle

(b) Lean Hog

(c) Feeder Cattle

(d) Kansas City Wheat

Appendix B: Daily Volume Percentages for ATS–ATS, ATS–MAN, and MAN–MAN, by Outright (RO) and Spread (SP)

Figure 8: RO–RO, Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)
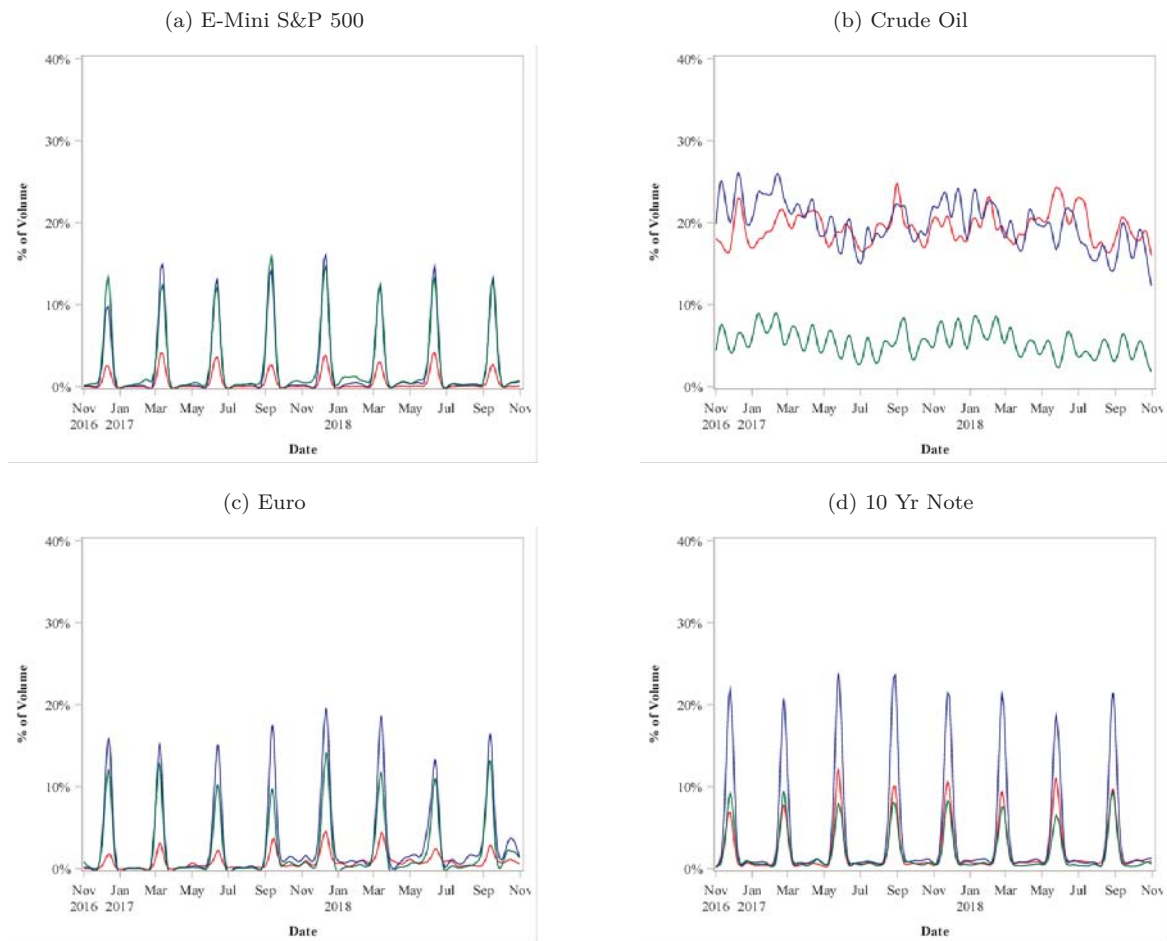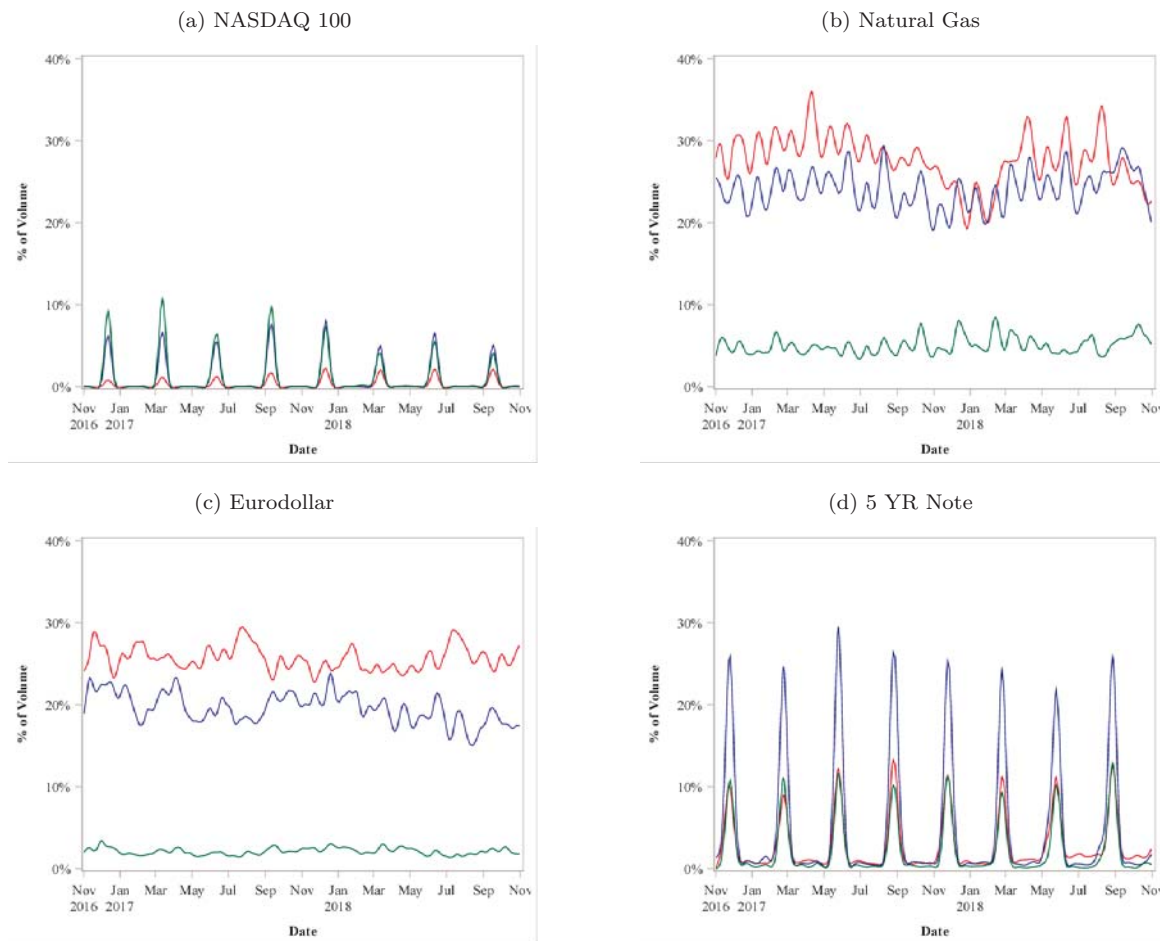
Notes: For each commodity, total daily volume linked to outright trades across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) E-Mini S&P 500

(b) Crude Oil

(c) Euro

(d) 10 Yr Note
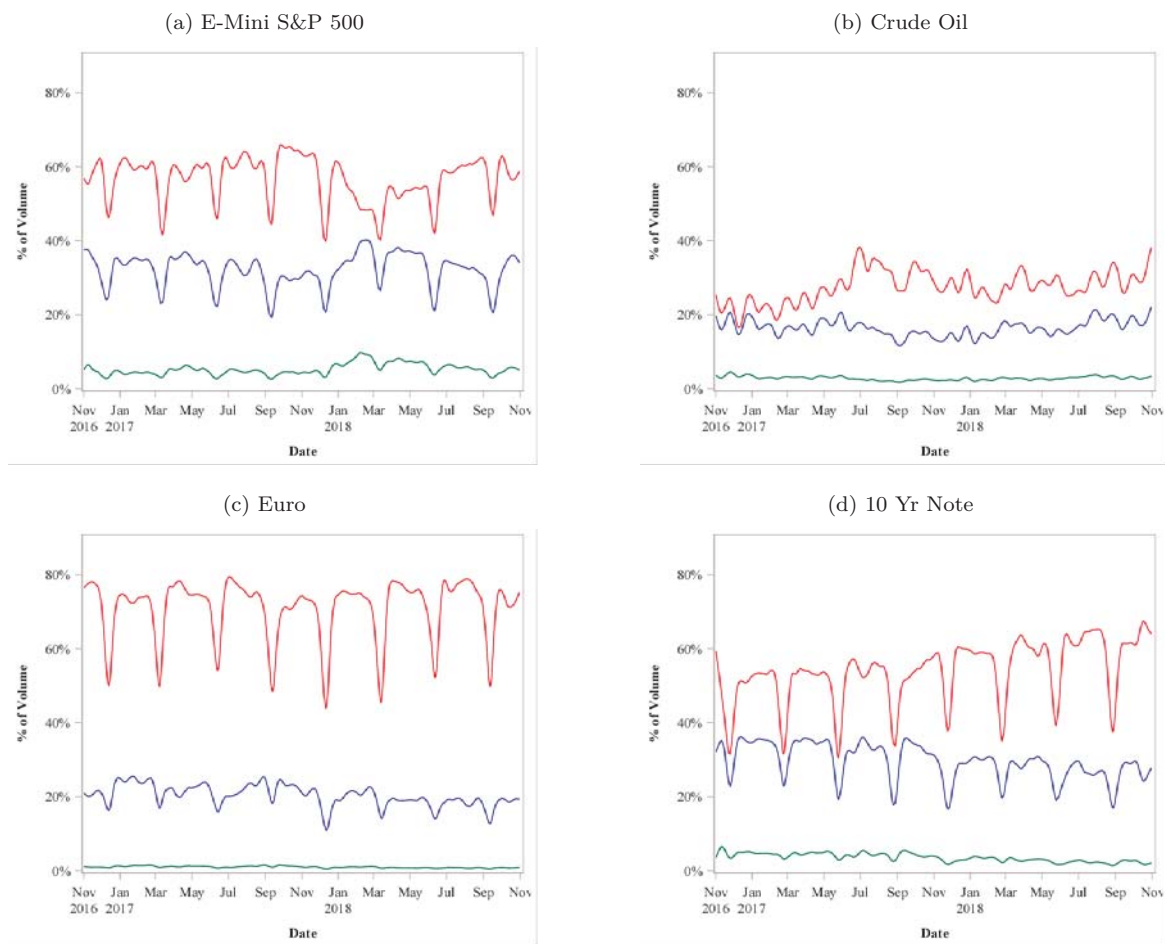
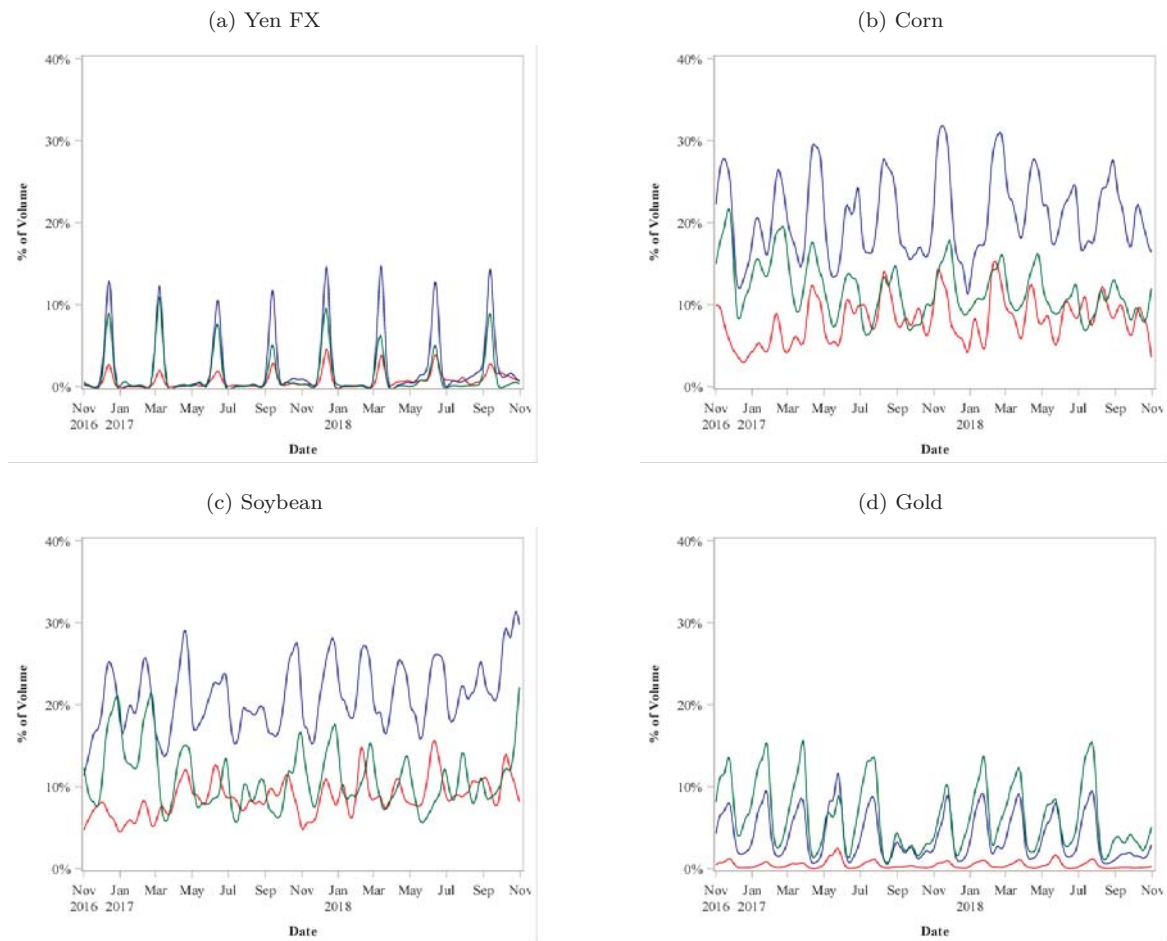Figure 9: RO–RO, Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)

Notes: For each commodity, total daily volume linked to outright trades across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) NASDAQ 100

(b) Natural Gas

(c) Eurodollar

(d) 5 YR Note

Figure 10: RO–RO, Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)

Notes: For each commodity, total daily volume linked to outright trades across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) Yen FX

(b) Corn

(c) Soybean

(d) Gold

Figure 11: RO–RO, Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)

Notes: For each commodity, total daily volume linked to outright trades across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) Silver

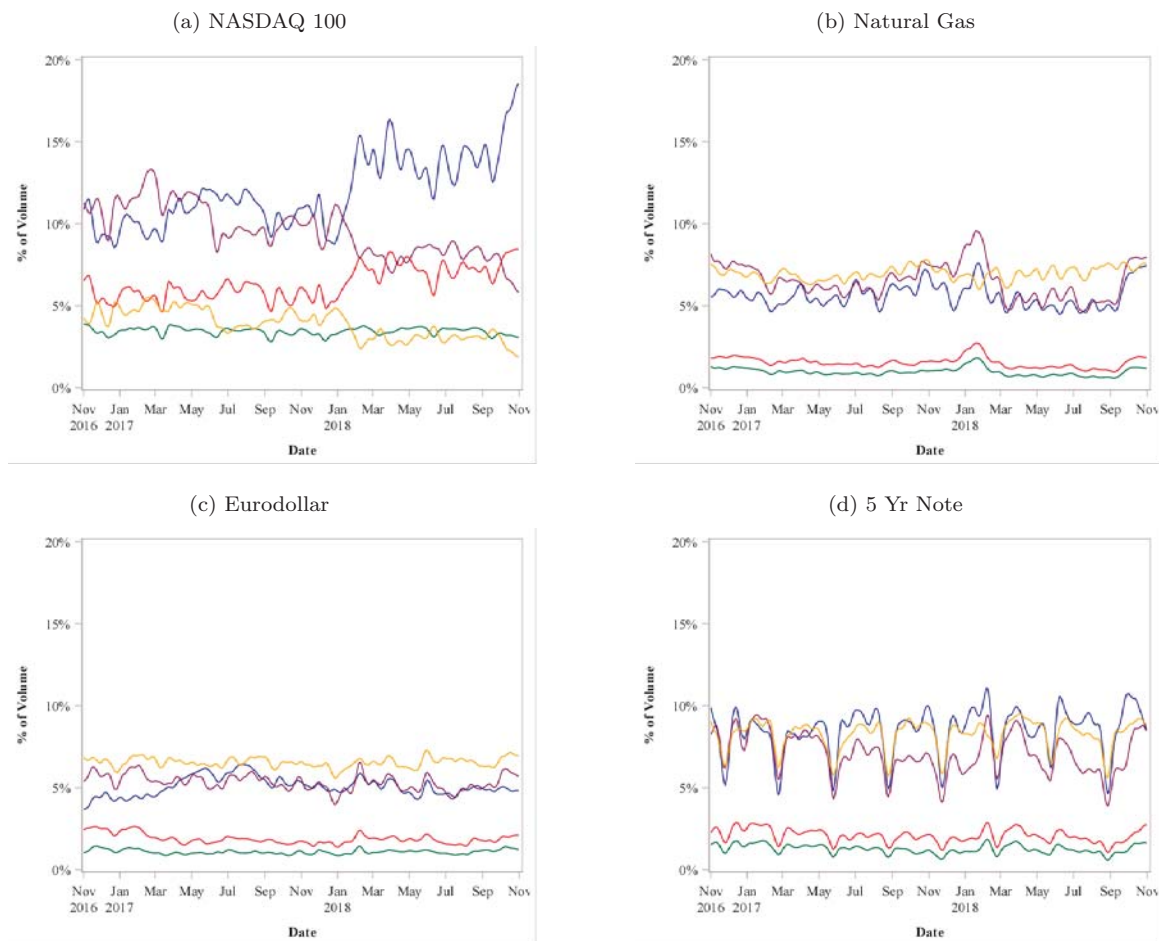Figure 12: SP–SP, Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)

Notes: For each commodity, total daily volume linked to intracommodity spreads across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) E-Mini S&P 500

(b) Crude Oil

(c) Euro

(d) 10 Yr Note

Figure 13: SP–SP, Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)

Notes: For each commodity, total daily volume linked to intracommodity spreads across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) NASDAQ 100

(b) Natural Gas

(c) Eurodollar

(d) 5 YR Note

Figure 14: SP–SP, Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)

Notes: For each commodity, total daily volume linked to intracommodity spreads across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) Yen FX

(b) Corn

(c) Soybean

(d) Gold

28

Figure 15: SP–SP, Daily Volume Percentages for ATS–ATS (Red), ATS–MAN (Blue), and MAN–MAN (Green)

Notes: For each commodity, total daily volume linked to intracommodity spreads across all expirations is divided into trades where both sides result from an automated system (ATS–ATS), where one side is an automated system (ATS–MAN), neither side is an automated system (MAN–MAN), and non-electronic volume (not included in the figures below). Percentages are computed, then smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.
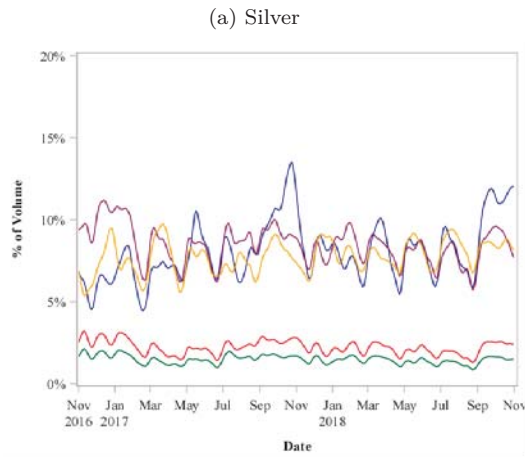
(a) Silver
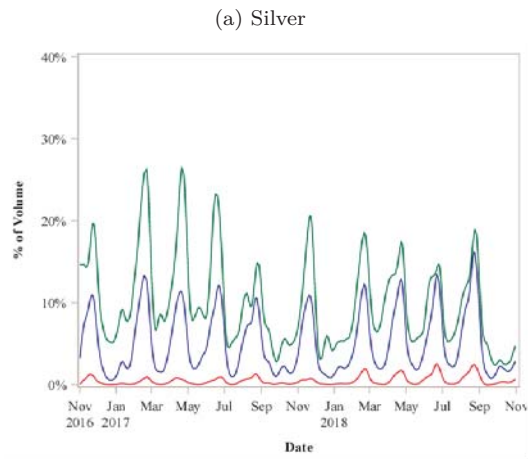
Appendix C: Additional Products: Daily Liquidity Provision of ATS by Time Groups

Figure 16: Daily Liquidity Provision of ATS by Time Groups

Notes: This figure summarizes the speed of passive order execution across four futures products. The time difference between passive order entry (or most recent modification) and trade execution is calculated for each transaction. These times are then grouped into five ranges: (1) 0 – 100 ms (Blue), (2) 101 ms – 500 ms (Red), (3) 501 ms – 1 s (Green), (4) 1.001 s – 10 s (Purple), and (5) 10.001 s – 60 s (Orange), and then charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.
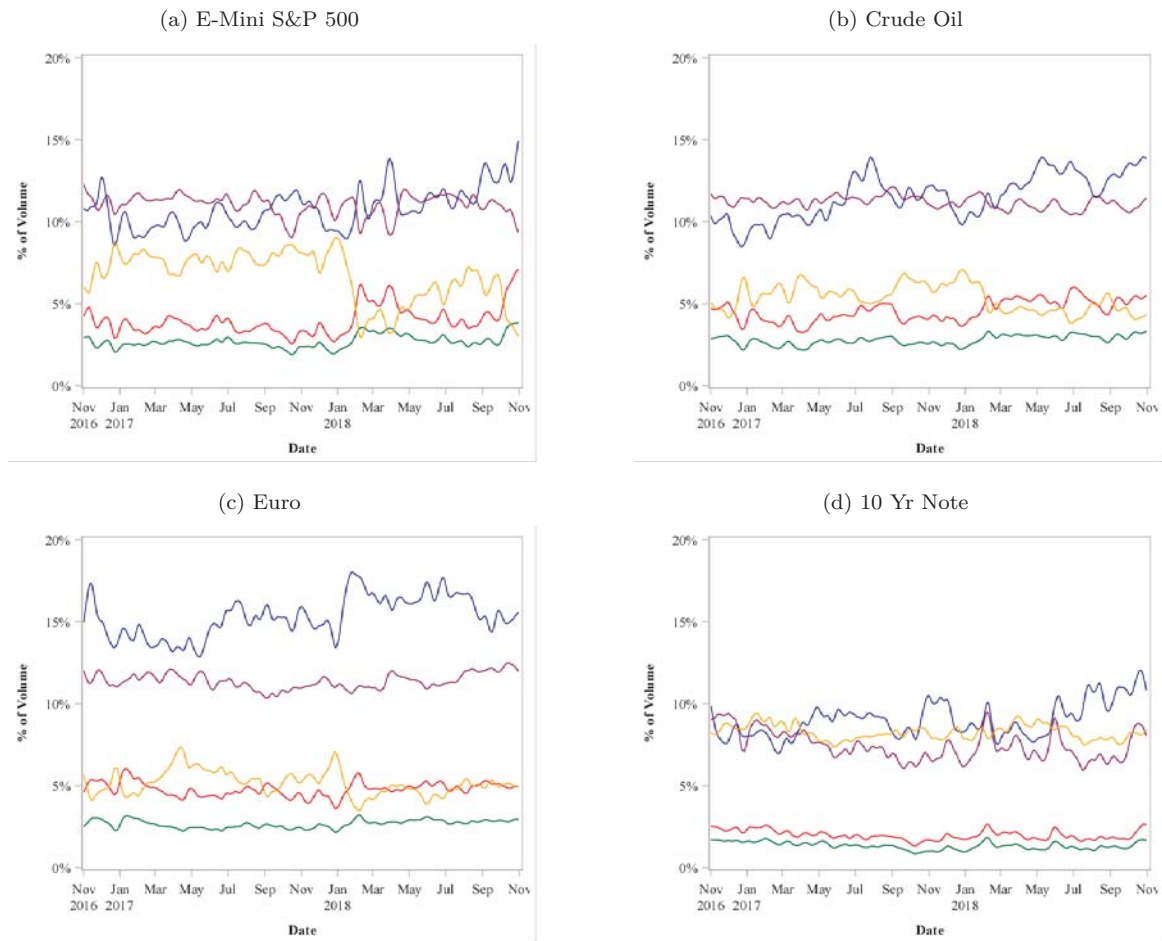
(a) NASDAQ 100

(b) Natural Gas

(c) Eurodollar

(d) 5 Yr Note

Figure 17: Daily Liquidity Provision of ATS by Time Groups
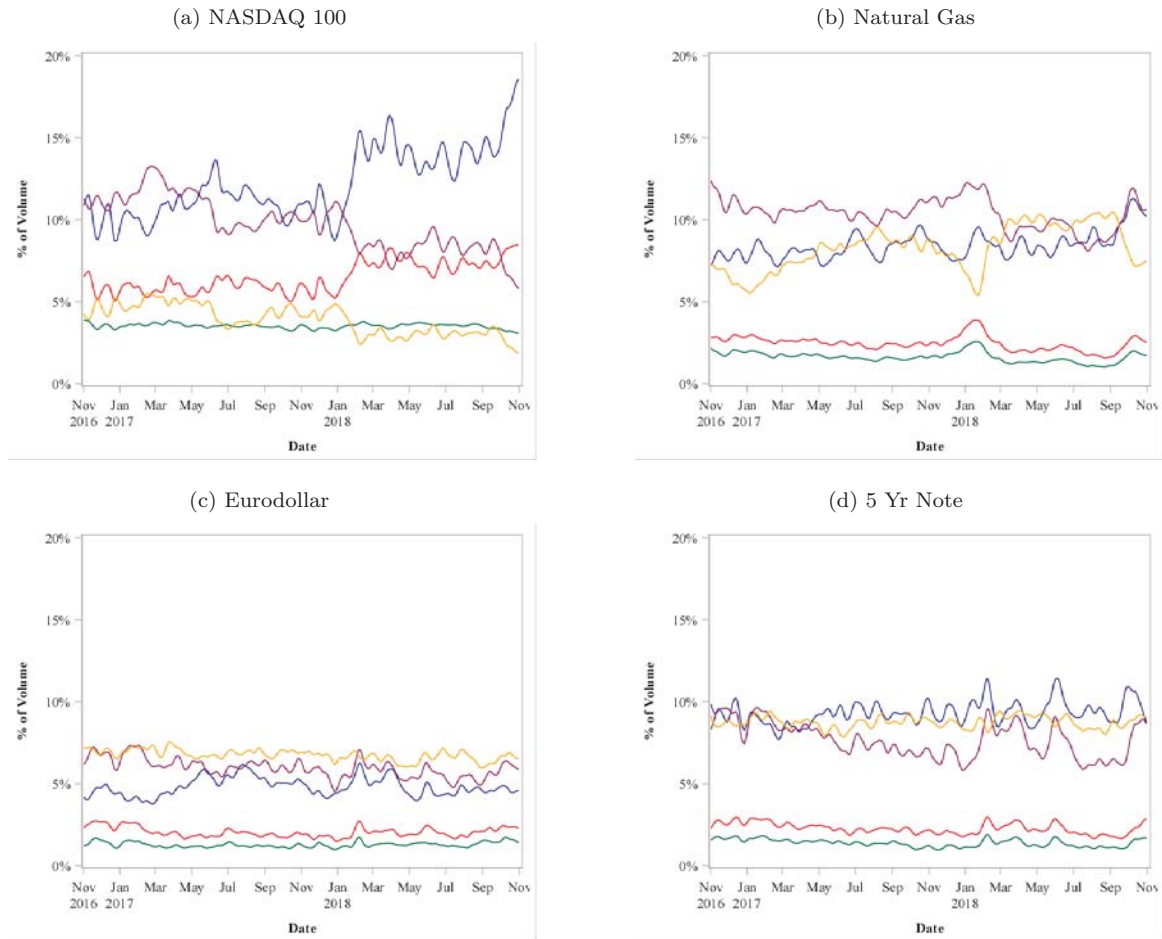
Notes: This figure summarizes the speed of passive order execution across four futures products. The time difference between passive order entry (or most recent modification) and trade execution is calculated for each transaction. These times are then grouped into five ranges: (1) 0 – 100 ms (Blue), (2) 101 ms – 500 ms (Red), (3) 501 ms – 1 s (Green), (4) 1.001 s – 10 s (Purple), and (5) 10.001 s – 60 s (Orange), and then charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) Yen FX

(b) Corn

(c) Soybean

(d) Gold

Figure 18: Daily Liquidity Provision of ATS by Time Groups

Notes: This figure summarizes the speed of passive order execution across four futures products. The time difference between passive order entry (or most recent modification) and trade execution is calculated for each transaction. These times are then grouped into five ranges: (1) 0 − 100 ms (Blue), (2) 101 ms − 500 ms (Red), (3) 501 ms − 1 s (Green), (4) 1.001 s − 10 s (Purple), and (5) 10.001 s − 60 s (Orange), and then charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 − October 31, 2018.

(a) Silver

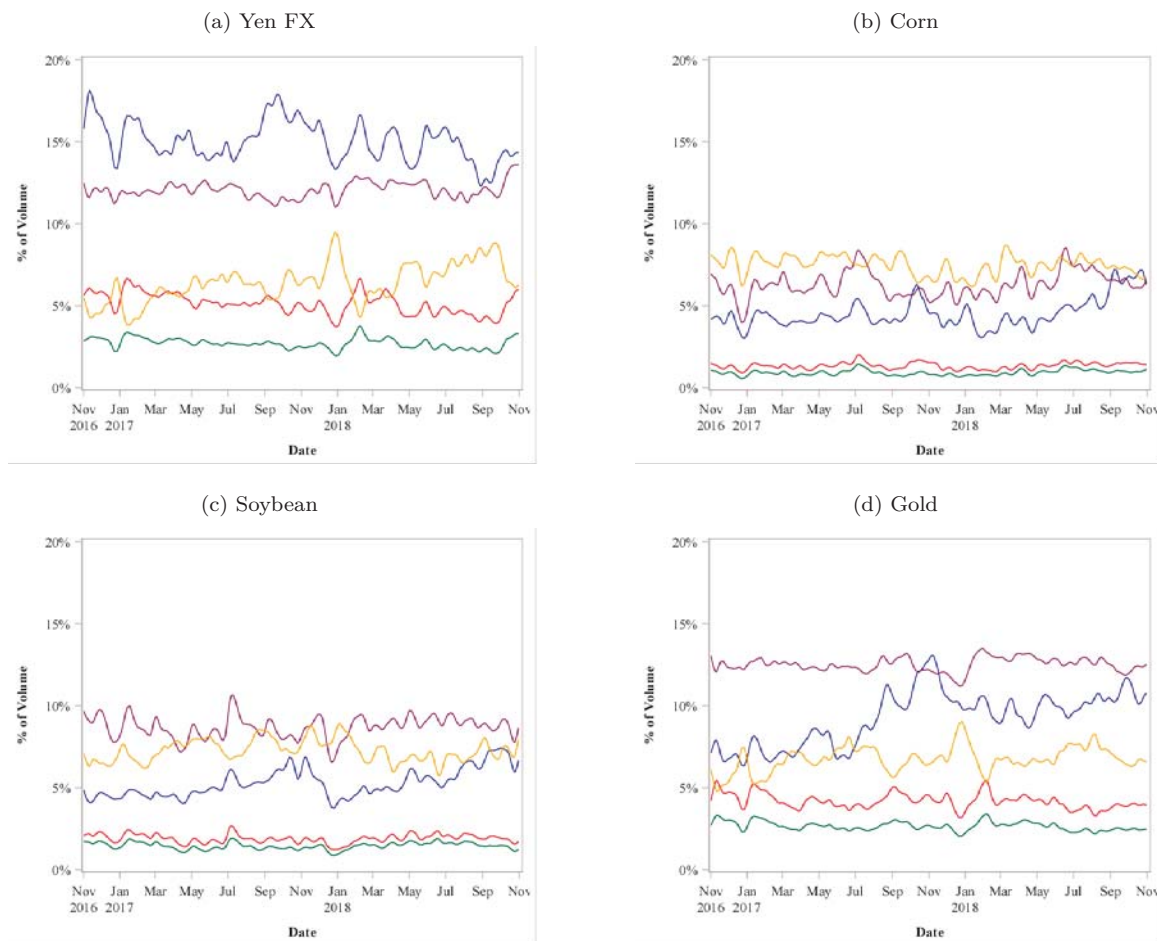Figure 19: Outright Volume: Daily Liquidity Provision of ATS by Time Groups

Notes: This figure summarizes the speed of passive order execution across four futures products for outright trades. The time difference between passive order entry (or most recent modification) and trade execution is calculated for each transaction. These times are then grouped into five ranges: (1) 0 – 100 ms (Blue), (2) 101 ms – 500 ms (Red), (3) 501 ms – 1 s (Green), (4) 1.001 s – 10 s (Purple), and (5) 10.001 s – 60 s (Orange), and then charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) E-Mini S&P 500

(b) Crude Oil

(c) Euro

(d) 10 Yr Note

Figure 20: Outright Volume: Daily Liquidity Provision of ATS by Time Groups

Notes: This figure summarizes the speed of passive order execution across four futures products for outright trades. The time difference between passive order entry (or most recent modification) and trade execution is calculated for each transaction. These times are then grouped into five ranges: (1) 0 – 100 ms (Blue), (2) 101 ms – 500 ms (Red), (3) 501 ms – 1 s (Green), (4) 1.001 s – 10 s (Purple), and (5) 10.001 s – 60 s (Orange), and then charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.
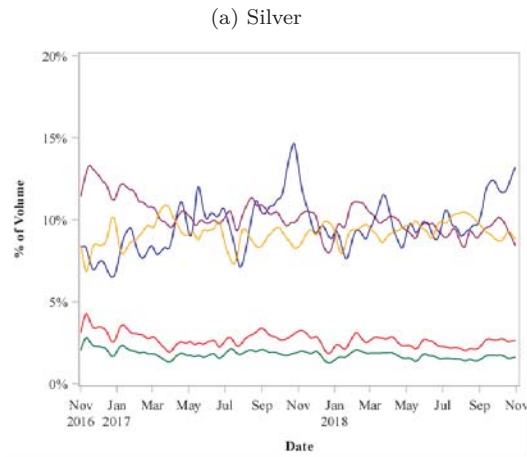
(a) NASDAQ 100

(b) Natural Gas

(c) Eurodollar

(d) 5 Yr Note

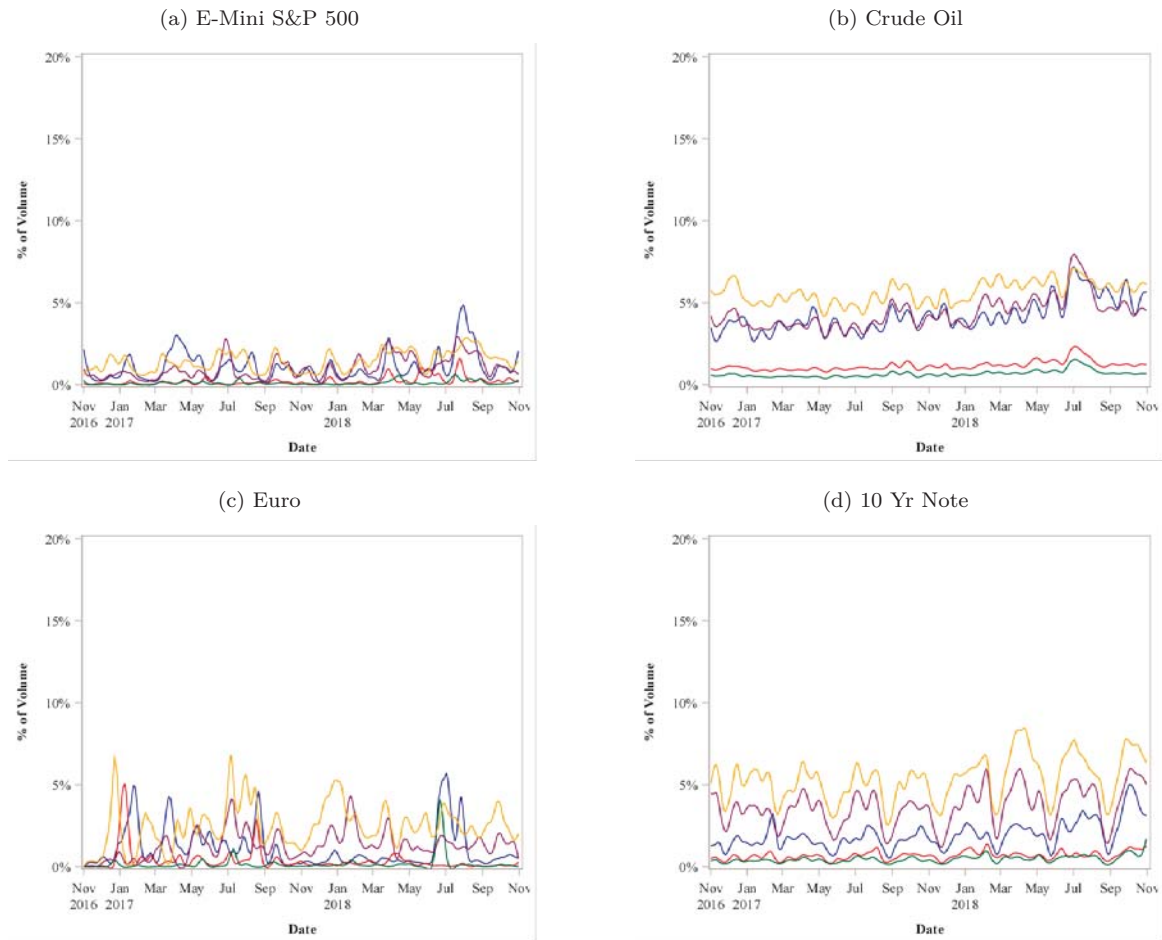Figure 21: Outright Volume: Daily Liquidity Provision of ATS by Time Groups

Notes: This figure summarizes the speed of passive order execution across four futures products for outright trades. The time difference between passive order entry (or most recent modification) and trade execution is calculated for each transaction. These times are then grouped into five ranges: (1) 0 – 100 ms (Blue), (2) 101 ms – 500 ms (Red), (3) 501 ms – 1 s (Green), (4) 1.001 s – 10 s (Purple), and (5) 10.001 s – 60 s (Orange), and then charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) Yen FX

(b) Corn

(c) Soybean

(d) Gold

35

Figure 22: Outright Volume: Daily Liquidity Provision of ATS by Time Groups

Notes: This figure summarizes the speed of passive order execution across four futures products for outright trades. The time difference between passive order entry (or most recent modification) and trade execution is calculated for each transaction. These times are then grouped into five ranges: (1) 0 – 100 ms (Blue), (2) 101 ms – 500 ms (Red), (3) 501 ms – 1 s (Green), (4) 1.001 s – 10 s (Purple), and (5) 10.001 s – 60 s (Orange), and then charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) Silver

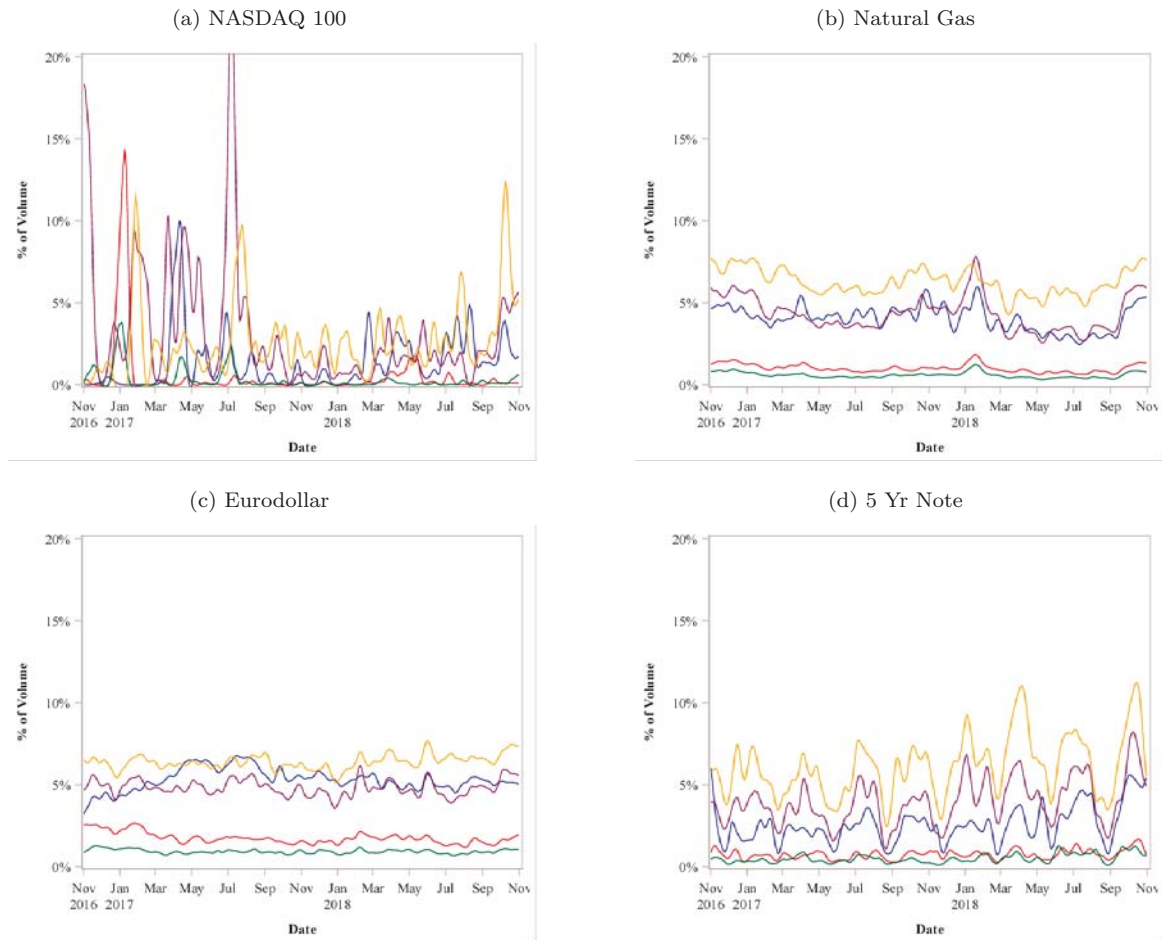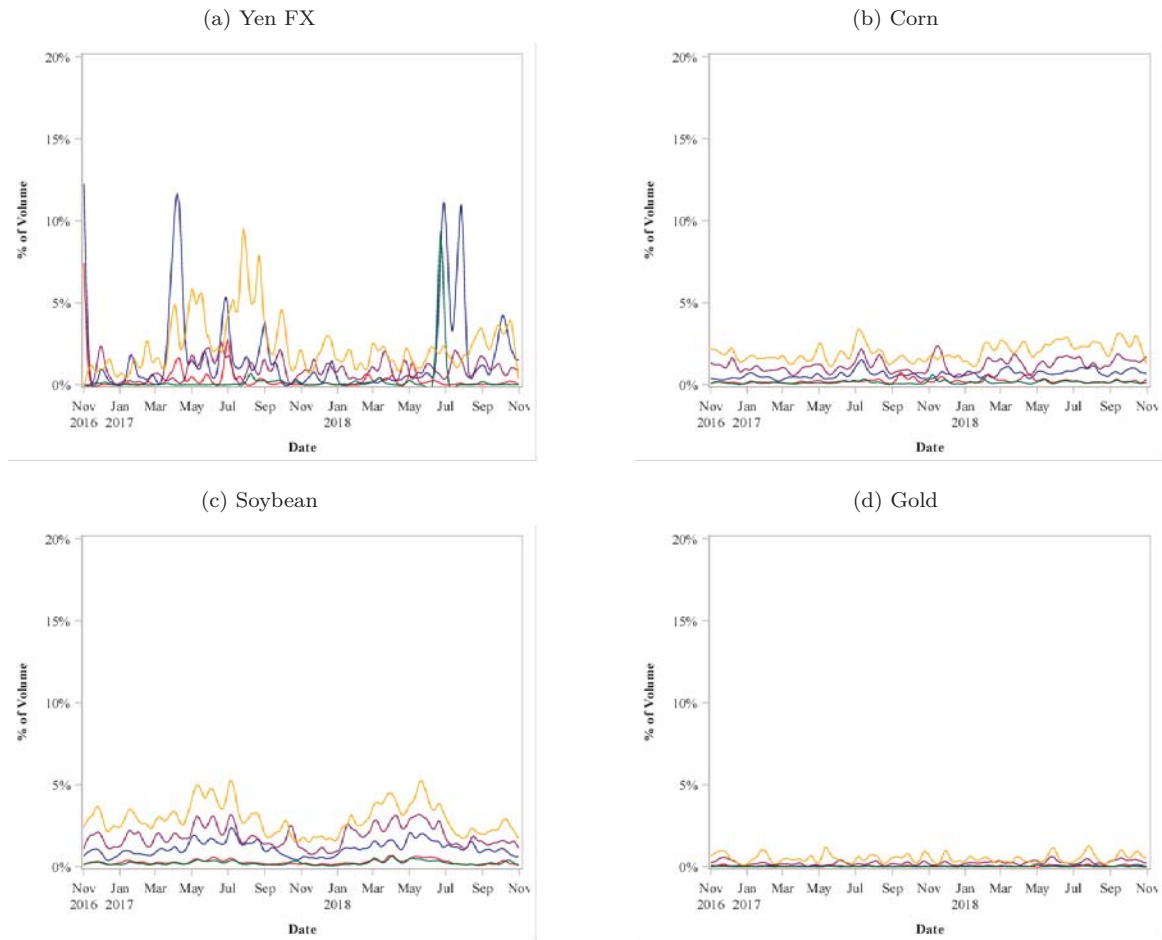Figure 23: Spread Volume: Daily Liquidity Provision of ATS by Time Groups

Notes: This figure summarizes the speed of passive order execution across four futures products for intracommodity spread trades. The time difference between passive order entry (or most recent modification) and trade execution is calculated for each transaction. These times are then grouped into five ranges: (1) 0 – 100 ms (Blue), (2) 101 ms – 500 ms (Red), (3) 501 ms – 1 s (Green), (4) 1.001 s – 10 s (Purple), and (5) 10.001 s – 60 s (Orange), and then charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) E-Mini S&P 500

(b) Crude Oil

(c) Euro

(d) 10 Yr Note

Figure 24: Spread Volume: Daily Liquidity Provision of ATS by Time Groups

Notes: This figure summarizes the speed of passive order execution across four futures products for intracommodity spread trades. The time difference between passive order entry (or most recent modification) and trade execution is calculated for each transaction. These times are then grouped into five ranges: (1) $0 - 100$ ms (Blue), (2) 101 ms $- 500$ ms (Red), (3) 501 ms $- 1$ s (Green), (4) 1.001 s $- 10$ s (Purple), and (5) 10.001 s $- 60$ s (Orange), and then charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 $-$ October 31, 2018.

(a) NASDAQ 100

(b) Natural Gas

(c) Eurodollar

(d) 5 Yr Note

Figure 25: Spread Volume: Daily Liquidity Provision of ATS by Time Groups

Notes: This figure summarizes the speed of passive order execution across four futures products for intracommodity spread trades. The time difference between passive order entry (or most recent modification) and trade execution is calculated for each transaction. These times are then grouped into five ranges: (1) 0 – 100 ms (Blue), (2) 101 ms – 500 ms (Red), (3) 501 ms – 1 s (Green), (4) 1.001 s – 10 s (Purple), and (5) 10.001 s – 60 s (Orange), and then charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.
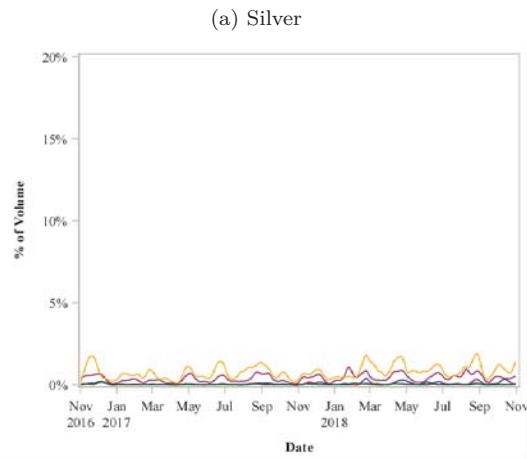
(a) Yen FX

(b) Corn

(c) Soybean

(d) Gold

Figure 26: Spread Volume: Daily Liquidity Provision of ATS by Time Groups

Notes: This figure summarizes the speed of passive order execution across four futures products for intracommodity spread trades. The time difference between passive order entry (or most recent modification) and trade execution is calculated for each transaction. These times are then grouped into five ranges: (1) 0 – 100 ms (Blue), (2) 101 ms – 500 ms (Red), (3) 501 ms – 1 s (Green), (4) 1.001 s – 10 s (Purple), and (5) 10.001 s – 60 s (Orange), and then charted as percentages of total volume for each trading day. The charts are smoothed in SAS according to a noniterative smoothing spline transformation (Reinsch; 1967) with smoothing parameter of 5. Source: CME transaction data, November 1, 2016 – October 31, 2018.
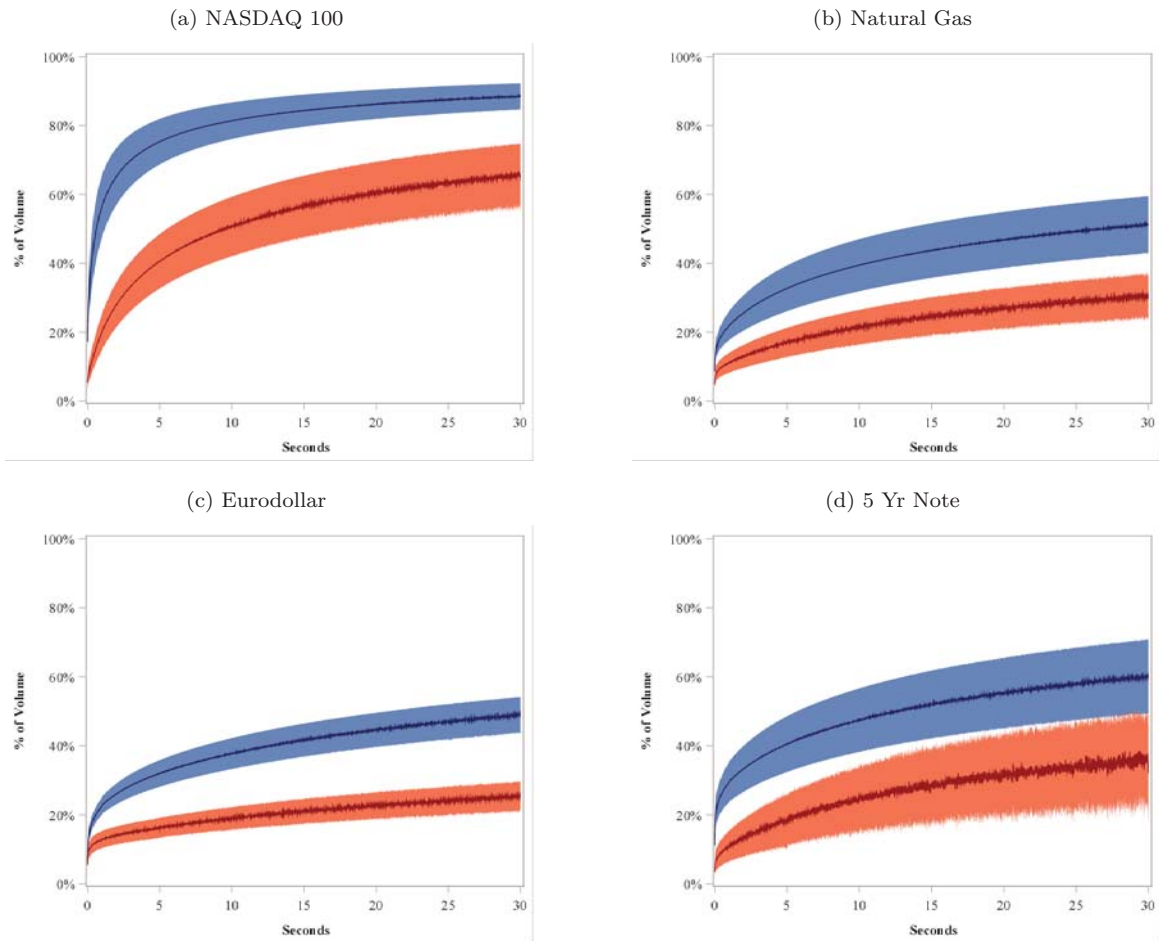
(a) Silver

Appendix D: Liquidity Provision Time Between Order Placement and Execution

Figure 27: Liquidity Provision Time Between Order Placement and Execution for ATS (Blue) and Manual (Red)
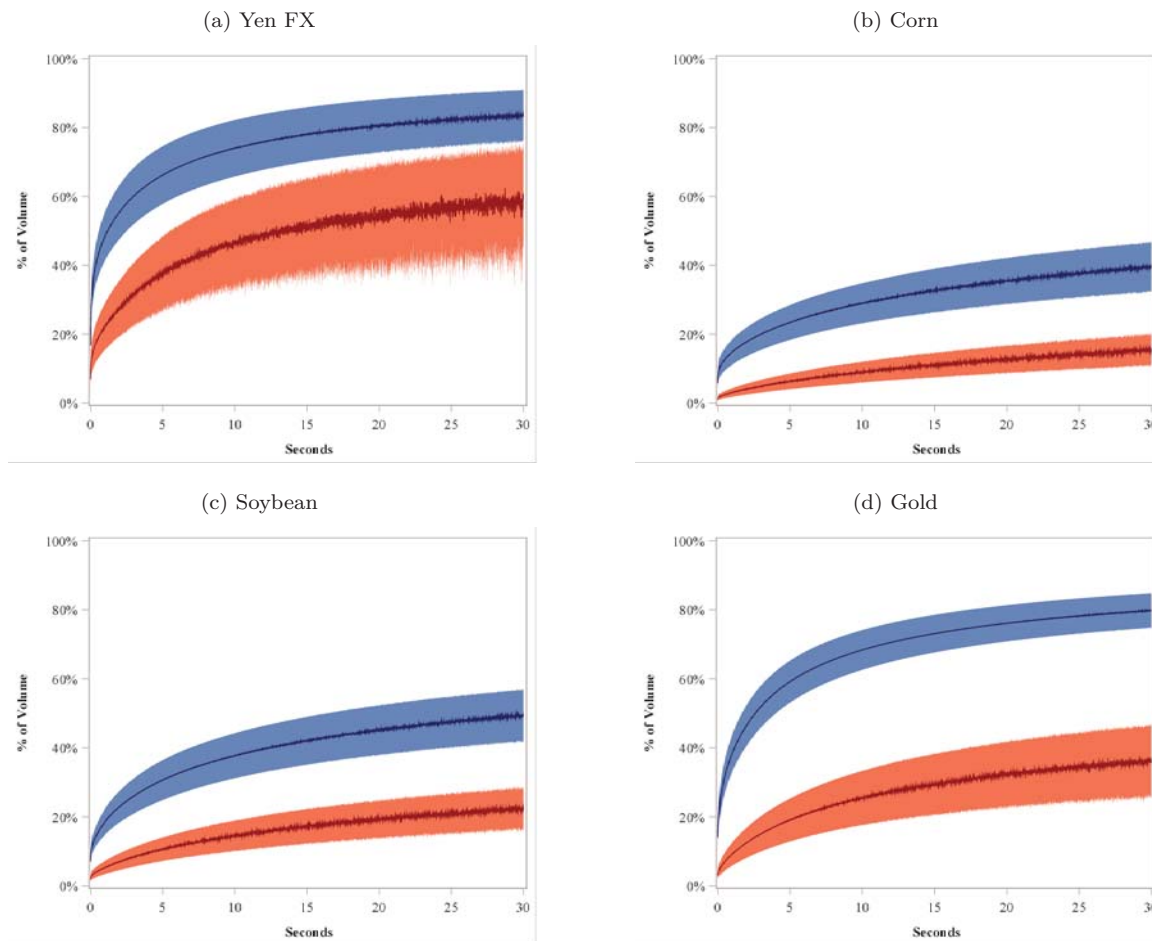
Notes: This figure summarizes the cumulative volume of passive execution across four futures contracts. For each transaction the time between order entry (or most recent modification) and execution was computed. These differences were rounded to the nearest 10 ms and ordered by increasing time. From this ordered set, the cumulative volume as a percent of total in both the ATS or MAN categories is charted. The bands show 1 standard deviation above and below the average across the sample period. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) NASDAQ 100

(b) Natural Gas

(c) Eurodollar

(d) 5 Yr Note

Figure 28: Liquidity Provision Time Between Order Placement and Execution for ATS (Blue) and Manual (Red)

Notes: This figure summarizes the cumulative volume of passive execution across four futures contracts. For each transaction the time between order entry (or most recent modification) and execution was computed. These differences were rounded to the nearest 10 ms and ordered by increasing time. From this ordered set, the cumulative volume as a percent of total in both the ATS or MAN categories is charted. The bands show 1 standard deviation above and below the average across the sample period. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) Yen FX

(b) Corn

(c) Soybean

(d) Gold

Figure 29: Liquidity Provision Time Between Order Placement and Execution for ATS (Blue) and Manual (Red)

Notes: This figure summarizes the cumulative volume of passive execution across four futures contracts. For each transaction the time between order entry (or most recent modification) and execution was computed. These differences were rounded to the nearest 10 ms and ordered by increasing time. From this ordered set, the cumulative volume as a percent of total in both the ATS or MAN categories is charted. The bands show 1 standard deviation above and below the average across the sample period. Source: CME transaction data, November 1, 2016 – October 31, 2018.

(a) Silver