Intraday Seasonality in Efficiency, Liquidity, Volatility and Volume: Platinum and Gold Futures in Tokyo and New York

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Introduction

- Why do multiple exchanges that trade the same commodity futures exist?
  - Many exchanges have extended their trading times to include night sessions, overlapping trading with each other.
  - Arbitrage activity means that the price of a commodity's future on different exchanges is virtually identical.
- A straightforward argument is that market participants should prefer to trade on the exchange with superior price discovery, efficiency and liquidity.
  - Trade in the futures of a particular commodity would be expected to agglomerate to one exchange, as higher liquidity and scale economies encourage traders to the venue.
- However, many futures exchanges that trade the same commodity persist.

Approach in this Research

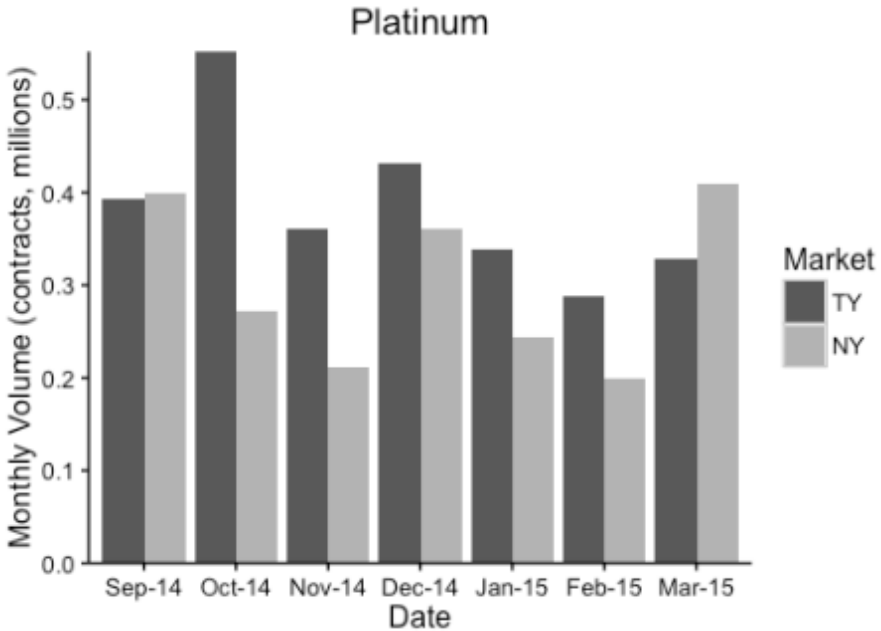
- Do markets for commodities futures contracts on different exchanges have different microstructure characteristics?
  - Differentiated characteristics may be advantageous for certain investors, and provide a competitive advantage for the exchange.
- We estimate and compare the intraday seasonality patterns for informational efficiency, volatility, volume and liquidity in platinum and gold futures traded in overlapping sessions on exchanges in Tokyo and New York.
- Look at the prevalence and patterns of informed versus uninformed (or liquidity) trading.

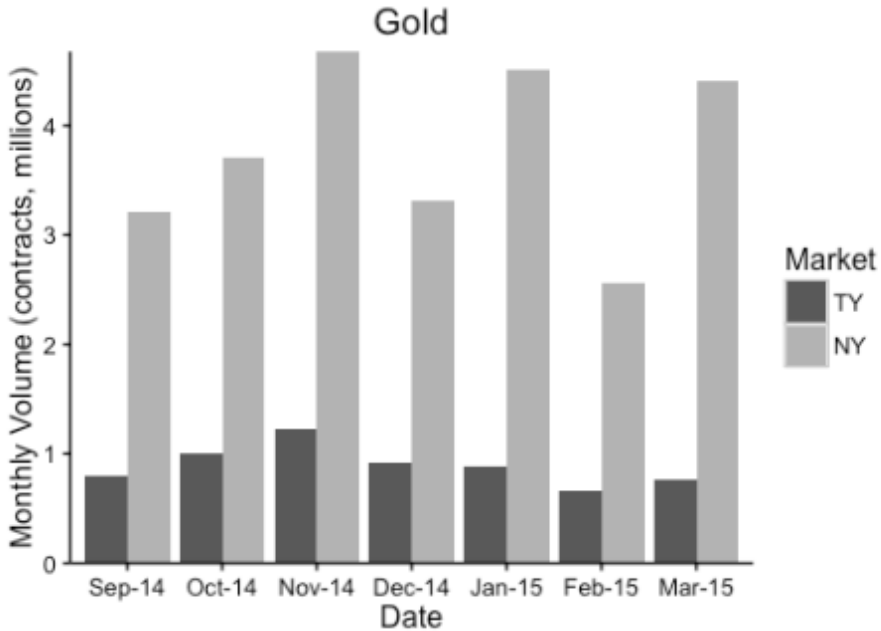
Platinum & Gold Futures in Tokyo and New York

- Why platinum and gold, New York and Tokyo?
- Trade in platinum is relatively centralised with Tokyo and New York being important markets.
  - In comparison, trade in gold is relatively decentralised.
- Tokyo is a globally important market for platinum futures, but not for gold.
  - Large consumers of, and traders in, physical platinum use the Tokyo market for hedging.
  - TOCOM has historically been an important venue for platinum hedging, primarily for Japanese firms but the market has become more internationalised over recent years.
  - Despite a decline in volumes, TOCOM retains a not insubstantial share of the global platinum futures trade.
- Hence, platinum and gold, Tokyo and New York, provide an interesting comparison.

Platinum & Gold Futures in Tokyo and New York

- Platinum futures are traded on TOCOM and NYMEX.
  - Platinum contract volumes are similar on each exchange, but the NYMEX contract represents about 3.1 times the weight of metal in the TOCOM contract.
- Gold futures are traded on TOCOM and COMEX.
  - COMEX contract volumes are substantially higher than TOCOM, and COMEX contracts represent 3.11 times the weight of metal in TOCOM contracts.





Platinum & Gold Futures in Tokyo and New York

- Actively traded maturities differ between the exchanges in Tokyo and New York for both metals:
  - The deferred contract months (farthest & 4^{th} back) in Toyko.
  - The nearby contract months (nearby & 1^{st} back) in New York.
- We use the nearby contract for New York and the deferred (or farthest) contract for Tokyo.
- The trading hours of the exchanges overlap:
  - TOCOM holds both day and night trading sessions.
  - During TOCOM trading hours, the New York exchanges are also open.

Literature: Intraday Patterns

- Persistent intraday patterns exist in market microstructure characteristics such as return volatility, traded volume and liquidity.

- Intraday seasonality in the stock markets:
  - Volatility and volume: U shape (Andersen and Bollerslev (1997); Goodhart and Hara (1997); and others); reverse-J shape (Hussain (2011) for DAX index; Harju and Hussain (2011) for European equity indices).

  - Bid-ask spreads: U shape (Brock and Kleidon (1992) for US; Ahn and Cheung (1999) for Hong Kong and Japan); reverse-J shape (McInish and Wood (1992) for NYSE).

Literature: Intraday Patterns

- Continuous OTC trade in the foreign exchange market (Ito and Hashimoto 2006):
  - Contrary to equity markets, bid-ask spreads are low when volatility is high.
  - Trading volume has a U-shape pattern during Tokyo and London working hours, but not in NY.
- In one of the few papers to analyse intraday patterns in a commodity markets, Eaves and Williams (2010) observe U-shaped intraday volume and L-shaped return volatility on the Tokyo Grain Exchange.

Literature: Intraday Relationships Between Microstructure Characteristics

- Efficiency and volatility:
  - Positive: "Efficient market hypothesis".
    - Volatility results from new information being incorporated into market prices.
  - Negative: "Noise trader hypothesis".
    - Noise traders transact irrationally, which leads to volatility.

Literature: Intraday Relationships Between Microstructure Characteristics

- Efficiency and volume:
  - Positive: "Asymmetric information view" (Admati and Pfleiderer 1988).
    - Liquidity traders prefer to trade when they have little price impact. More liquidity trading induces informed traders to transact, contributing to improving informational efficiency.
  - Negative: "Inventory control view" (Lyons 1997).
    - Passing of unwanted positions from dealer to dealer reduces the informativeness of prices.

Literature: Intraday Relationships Between Microstructure Characteristics

- Efficiency and liquidity:
  - Positive: "Transaction cost view" (Kyle 1985).
    - Greater market liquidity reduces transaction costs for informed traders, and their trades contribute to informational efficiency.
  - Negative: "Noise trader view" (Tetlock 2007).
    - Liquidity is a proxy for uninformed trading and thus is associated with informed efficiency.

Relationships – Microstructure Characteristics

Correlation of Efficiency with	Positive (Informed Trading)	Negative (Uninformed Trading)
Volatility	Efficient Markets Hypothesis: volatility reflects the rational adjustment of prices to new information, and thus is associated with efficiency.	Noise Trader Hypothesis: volatility reflects the irrational transactions of noise traders, and thus is associated with inefficiency.
Volume	Asymmetric Information View (Admati & Pfleiderer, 1988): liquidity traders prefer to trade when they have little price impact. More liquidity trading induces informed traders to transact, contributing to improved informational efficiency.	Inventory Control View (Lyons, 1997): passing of unwanted positions from dealer to dealer during high volume periods reduces the informativeness of prices (pass the hot potato).
Liquidity	Transactions Cost View (Kyle 1988): greater market liquidity reduces transaction costs for informed traders, and their trades contribute to informational efficiency.	Noise Trader View (Tetlock, 2007): suggests that liquidity is a proxy for the transactions of uninformed traders, and thus associated with inefficiency.

Data

- 1 minute bid and ask futures prices and trading volume over the sample 1 September 2014 to 31 March 2015 (128 days).
- Use the most traded contracts on each exchange:
  - Far contract on TOCOM.
  - Near contract for NYMEX and COMEX.
- Trading hours are defined by TOCOM's hours:
  - Day session 9:00 to 15:15
  - Night session 16:30 to 4:00 (total 1065 minutes of trading).
- We split each trading day into nine time intervals (TI):
  - TI1 to TI3 cover the TOCOM day session (125 minutes each).
  - TI4 to TI9 cover the TOCOM night session (115 minutes).
    - TI4 to TI6 referred to as the London day session.
    - TI7 to TI9 referred to as the New York day session.

Time Intervals

Time Interval	Duration (minutes)	Tokyo (JST)		London (GMT)		New York (EST)	
		Start Time	End Time	Start Time	End Time	Start Time	End Time
TI1	125	9:00:00	11:04:59	0:00:00	2:04:59	-19:00:00	-21:04:59
TI2	125	11:05:00	13:09:29	2:05:00	4:09:59	-21:05:00	-23:09:59
TI3	125	13:10:00	15:14:59	4:10:00	6:14:59	-23:10:00	1:14:59
TI4	115	16:30:00	18:24:59	7:30:00	9:24:59	2:30:00	4:24:59
TI5	115	18:25:00	20:19:59	9:25:00	11:19:59	4:25:00	6:19:59
TI6	115	20:20:00	22:14:59	11:20:00	13:14:59	6:20:00	8:14:59
TI7	115	22:15:00	+00:09:59	13:15:00	15:09:59	8:15:00	10:09:59
TI8	115	+00:10:00	+02:04:59	15:10:00	17:04:59	10:10:00	12:04:59
TI9	115	+02:05:00	+03:59:59	17:05:00	18:59:59	12:05:00	13:59:59

Variables

- Measures of informational inefficiency, volatility, volume, and two measures of illiquidity are calculated for the nine trading intervals over 128 days.

- Our construction of the variance ratio (VR) is used to measure **informational inefficiency**:

$$VR = \left| 1 - \frac{Var\left[r_t\left(5\right)\right]}{5 \times Var\left[r_t\right]} \right| \tag{1}$$

$$= \left| 1 - \frac{\frac{1}{T-5}\sum_{t=5}^{T}\left(r_t + r_{t-1} + r_{t-2} + r_{t-3} + r_{t-4} - 5\mu\right)^2}{\frac{5}{T-1}\sum_{t=1}^{T}\left(r_t - \mu\right)^2} \right| \tag{2}$$

- where $T = 125$ for TI1 to TI3, and $T = 115$ for TI4 to TI9.

Variables

- Realized volatility (Vol) is used to measure volatility.

$$Vol = 100\sqrt{\frac{1065}{T}\sum_{t=1}^{T} r_t^2} \tag{3}$$

- Trading volume (TV) is the average of 1-minute contract volumes.

$$TV = \frac{1}{T}\sum_{t=1}^{T} C_t \tag{4}$$

Variables

- Illiqidity is measured by the quoted half-spread (Sp) and Amihud's (2002) ILLIQ (ILLIQ).

$$Sp = \frac{1000}{2T} \sum_{t=1}^{T} \frac{p_t^{ask} - p_t^{bid}}{\left(p_t^{ask} + p_t^{bid}\right)/2} \tag{5}$$

- ILLIQ is the sum of five-minute returns over five minute volume of metal traded, in kilograms.

$$ILLIQ = 10^6 \times \frac{5}{T} \sum_{k=1}^{T/5} \frac{|r_t(5)_k|}{V_k} \tag{6}$$

Summary Statistics

- Platinum

Statistic	Variance Ratio TY	Variance Ratio NY	Realised Volatility TY	Realised Volatility NY	Trading Volume TY	Trading Volume NY	Spread TY	Spread NY	Illiquidity TY	Illiquidity NY
Mean	0.252	0.234	0.983	1.096	14.223	10.127	1.841	1.854	19.142	10.654
Median	0.239	0.209	0.872	0.976	10.400	6.625	1.875	1.802	12.613	8.603
Minimum	0.000	0.000	0.245	0.233	0.287	0.528	1.077	0.900	0.858	0.833
Maximum	0.965	0.932	9.823	9.152	131.040	60.278	3.447	3.890	180.336	52.357
Standard Deviation	0.170	0.165	0.628	0.656	13.082	9.471	0.261	0.416	20.105	7.855
Skewness	0.644	0.842	6.412	4.685	2.939	1.741	0.109	0.729	2.914	1.255
Kurtosis	0.159	0.567	73.100	44.166	13.860	3.469	3.208	0.830	12.853	1.725
Observations	1152	1152	1152	1152	1152	1152	1152	1152	1152	1152

- Gold

Statistic	Variance Ratio TY	Variance Ratio TY	Realised Volatility TY	Realised Volatility NY	Trading Volume TY	Trading Volume NY	Spread TY	Spread NY	Illiquidity TY	Illiquidity NY
Mean	0.270	0.225	0.845	0.924	34.456	125.895	1.277	0.539	4.958	0.843
Median	0.256	0.193	0.716	0.781	26.756	81.239	1.268	0.532	3.377	0.366
Minimum	0.000	0.000	0.229	0.192	1.826	0.328	1.082	0.442	0.544	0.074
Maximum	0.879	0.907	12.630	11.587	219.360	807.609	1.755	1.286	63.842	56.556
Standard Deviation	0.177	0.169	0.613	0.652	27.120	121.566	0.086	0.076	5.587	3.901
Skewness	0.568	1.042	9.136	5.913	2.190	2.024	1.200	4.170	4.231	8.833
Kurtosis	-0.152	0.960	146.010	72.775	7.169	5.044	3.590	29.249	26.006	10.394
Observations	1152	1152	1152	1152	1152	1152	1152	1152	1152	1152

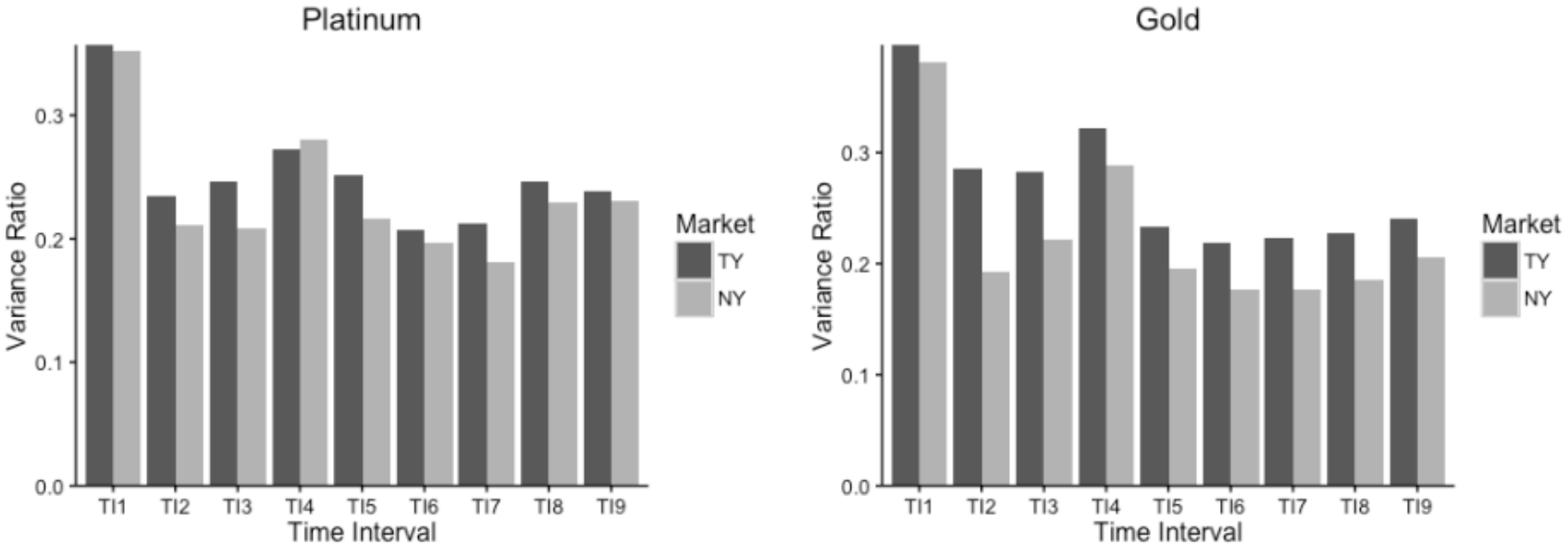
Regression Model

- The regression model used to estimate intraday seasonality:

$$y_{k,i,j} = \alpha_{k,1,1} + \sum_{i=2}^{9} \beta_{k,i} TI_i + \sum_{j=2}^{128} \gamma_{k,j} DD_j + \epsilon_{k,i,j} \qquad (7)$$

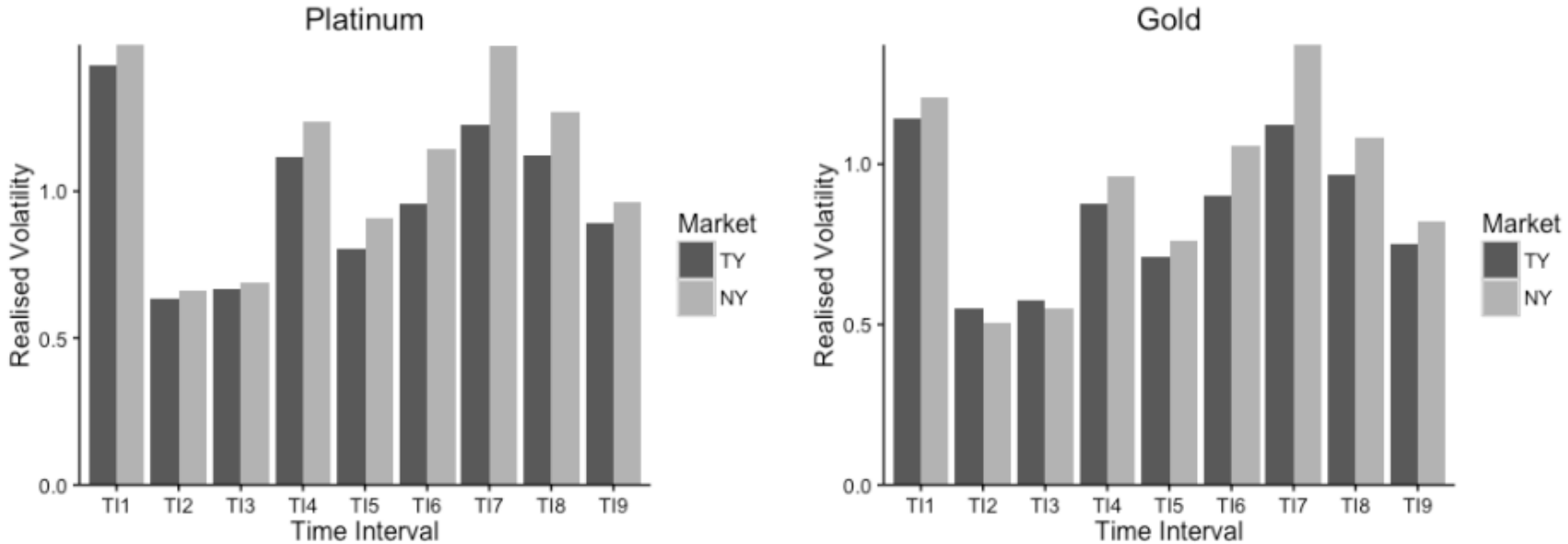
- $y_{k,i,j}$ is the microstructure variable for futures contract k at time i,j, where i refers to the time interval and j to the day.
- We regress the dependent variable on an intercept $\alpha_{k,1,1}$, dummy variables for the time intervals TI_i for i equal to two to nine (TI2 to TI9), and daily dummy variables DD_j for each of the j days in our sample from day two to day 128.
- The $\alpha_{k,1,1}$ and $\beta_{k,i}$ estimates represent the intraday seasonal patterns.

Empirical Results: Intraday Pattern of Inefficiency



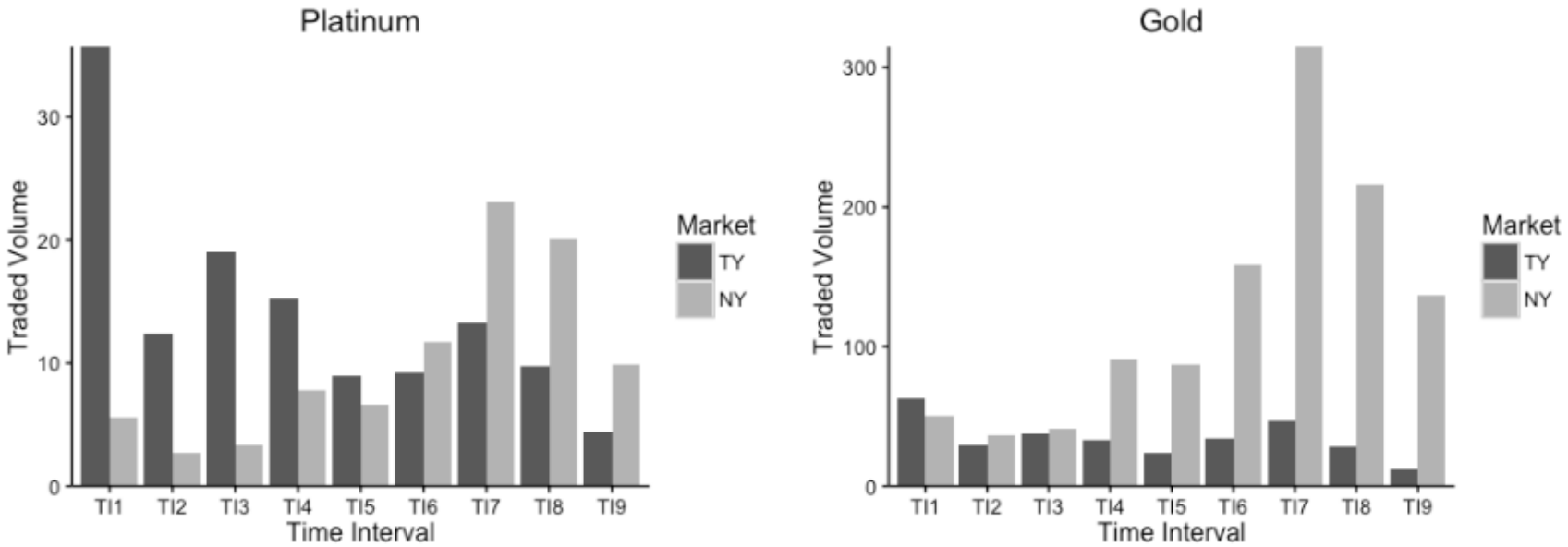
- TI1 is by far the least informationally efficient.
- Tokyo and London day sessions start of relatively inefficient.
- New York day session is relatively efficient at the open and is less efficient later.
- Efficiency difference between exchanges is greater for gold.
- W-shape pattern over the day.

Empirical Results: Intraday Pattern of Volatility



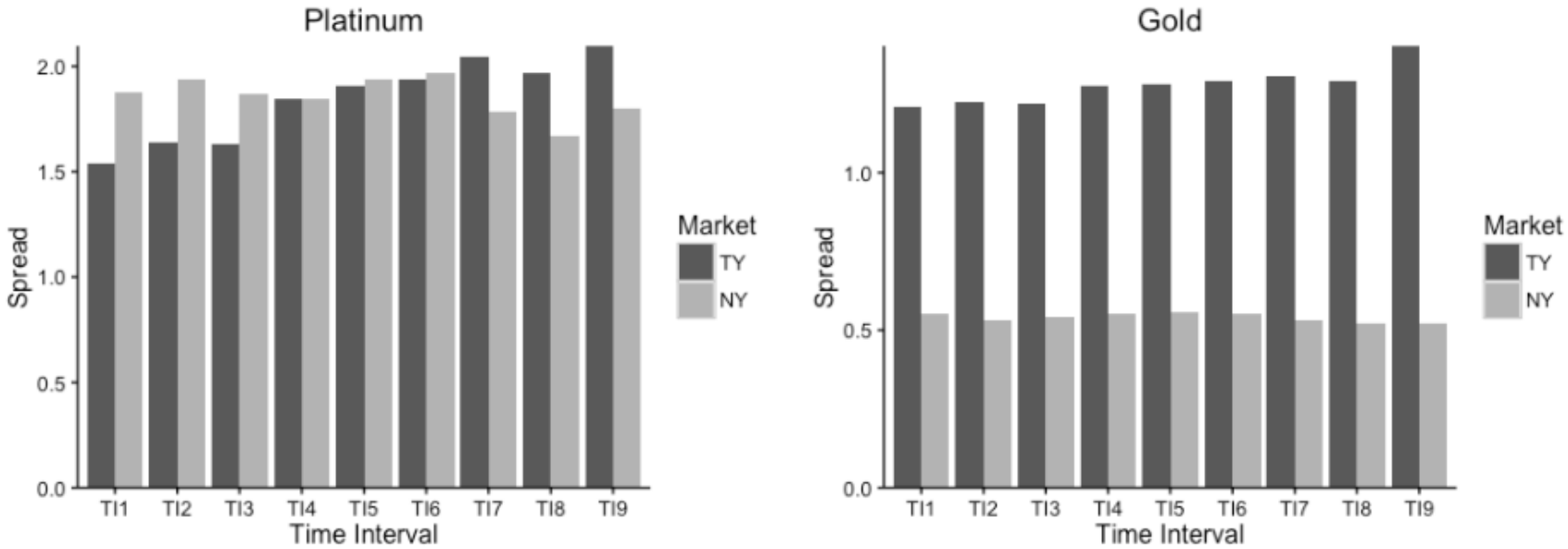
- Volatility peaks at the open of the Tokyo, London and New York day sessions for each market.
- Tokyo and New York open (TI1 and TI7) are the most volatile times, but generally volatility trends up over the day post TI1 until TI7, after which it declines.
- Similar pattern to that found in FX markets.

Empirical Results: Intraday Pattern of Trading Vol



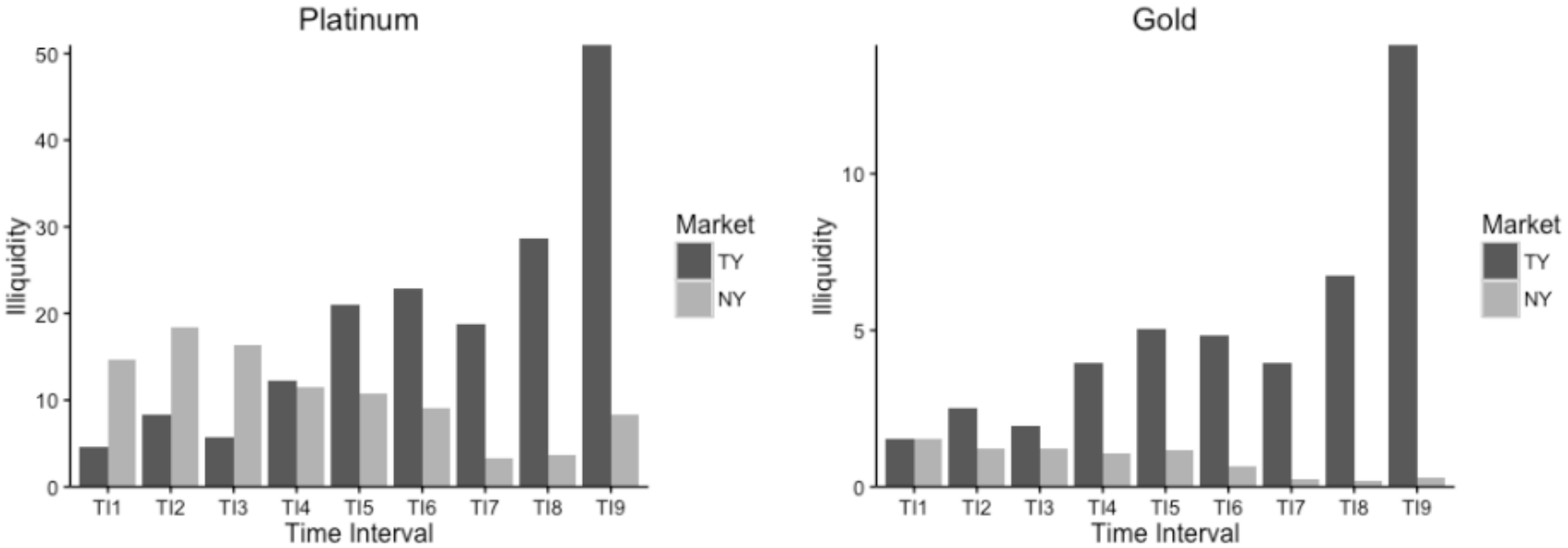
- Trading volume on each exchange is concentrated during that exchange's day session.
- For platinum, volumes are relatively high around the Tokyo and New York opens.

Empirical Results: Intraday Pattern of Spread



- Gold spreads in Tokyo are much larger than (about double) those for New York.
- In contrast, platinum spreads for Tokyo are lower than those on New York during the Tokyo day session, while this situation reverses during the New York day session.
  - Each platinum market is most liquid during it's day session.

Empirical Results: Intraday Pattern of ILLIQ



- Each exchange is more liquid during its own day session.
- While the Tokyo platinum market is more liquid than NY during the Tokyo day session, from TI5 NY is more liquid.
- New York is as liquid or more liquid than Tokyo in the gold market.

Empirical Results: Correlations Between Estimates

- Platinum

Correlation of Efficiency with	All Sessions (Full Day)		Tokyo Day Session		London Day Session		New York Day Session	
	Tokyo	New York	Tokyo	New York	Tokyo	New York	Tokyo	New York
Volatility (Realised Vol) *EMH vs NT*	**-0.151** ***	**-0.219** ***	**-0.370** ***	**-0.486** ***	-0.004	**-0.087** *	**0.113** **	**0.091** *
Volume (Traded Volume) *AI vs IC*	**-0.144** ***	**0.098** ***	**-0.223** ***	**-0.174** ***	0.007	**0.100** **	0.059	**0.099** *
Liquidity (Spread) *TC vs NT*	**-0.127** ***	-0.019	**-0.120** **	-0.029	-0.056	-0.030	-0.013	-0.047
Liquidity (Illiquidity) *TC vs NT*	**-0.087** ***	0.031	**-0.144** ***	**-0.187** ***	**-0.129** **	**0.090** *	0.022	0.081

Note: ***, **, and * denote significance of the Pearson correlation coefficient at the 1, 5 and 10 percent levels, respectively.

- Gold

Correlation of Efficiency with	All Sessions (Full Day)		Tokyo Day Session		London Day Session		New York Day Session	
	Tokyo	New York	Tokyo	New York	Tokyo	New York	Tokyo	New York
Volatility (Realised Vol) *EMH vs NT*	**-0.104** ***	**-0.222** ***	**-0.302** ***	**-0.503** ***	-0.078	**-0.170** ***	**0.209** ***	**0.156** ***
Volume (Traded Volume) *AI vs IC*	-0.041	**0.150** ***	-0.069	**-0.133** ***	0.019	0.028	**0.118** **	**0.163** ***
Liquidity (Spread) *TC vs NT*	**-0.123** ***	0.026	0.062	0.065	-0.012	-0.031	-0.051	-0.016
Liquidity (Illiquidity) *TC vs NT*	**-0.116** ***	0.037	**-0.108** **	0.059	**-0.115** **	-0.024	0.013	-0.009

Note: ***, **, and * denote significance of the Pearson correlation coefficient at the 1, 5 and 10 percent levels, respectively.

- Note that the variance ratio, spread and ILLIQ correlation signs have been flipped to for interpretation as efficiency and liquidity.

Empirical Results – Correlations

- Over the **full day (TI1-9)**, the gold and platinum markets on TOCOM are dominated by uninformed trading, while the New York exchanges reflect both informed and uninformed trading.

- During the **Tokyo day session (TI1-3)**, correlations for both the Tokyo and New York exchanges support uninformed (or liquidity) trader interpretations, to a greater extent for platinum than gold.
  - Consistent with anecdotal evidence that firms with large physical platinum exposures hedge via TOCOM early in the Tokyo morning, and that this drives activity in both exchanges.
  - More evidence for uninformed trading in platinum than gold.

Empirical Results – Correlations

- In the **London session (TI4-6)** the correlations are less definitive. There is some support for uninformed trade in both metals on both exchanges, however there is also evidence for informed trade in the New York platinum market.

- Informed trading appears to dominate both metals on both exchanges during the **New York day session (TI7-9)**.
  - These correlations suggest that liquidity traders are likely to be absent from the Tokyo market during the NY day session when volume and liquidity are low.
  - Informed traders in Tokyo trade during the New York day session in Tokyo market despite the relatively higher trading costs of doing so compared with the Tokyo day session.

Conclusion

- Futures markets for the same underlying commodity on different exchanges have different microstructure characteristics.
- Volume and liquidity have different intraday patterns in metals and exchanges.
- Microstructure relationships, whether trading is informed or uninformed, evolve over the trading day and are related to which exchange is most active at the time.
  - During the Tokyo day session trading on both exchanges is dominated by uninformed trading and during the New York day session the markets are dominated by informed trading.
  - Liquidity trading during the Tokyo session is more strongly supported for platinum, while informed trading during the New York session is better supported for gold.
- Tokyo may be characterised as a liquidity traders market, while for New York there is evidence for both informed and liquidity trading in both metals.