All the cool kids are night trading

Should the cool kids be night trading?

Challenges posed by disruptive technologies
Self-driving cars

- Need rules (algorithms) for what to do in the event of a collision
Self-driving cars

The Moral Machine

http://moralmachine.mit.edu/
All the cool kids are night trading
Day trading “is starting to feel positively quaint. Although the New York Stock Exchange and other markets still open and close with a bell each day, more traders ...are at their computers late into the night. They're reacting to crises in Japan and Libya...”
Should the cool kids be night trading?
Motivation

- Global financial markets involve traders who are *geographically dispersed in real time*.

- This raises an under-appreciated issue with implications for asset pricing in such global markets;

- *One likely to become more prominent with increasing globalization and improving technology.*
Motivation

- Specifically, the presence of globally dispersed traders implies

- different local times-of-day for those traders

- and, consequently, differences in circadian-driven sleepiness/alertness levels across these traders.
Motivation

- At 4:00 AM everyone is tired, no matter how much coffee you drink!

- So, what are the implications for markets and for individual traders of such night trading?
Major Findings

- The presence of traders at different times of day tend to exacerbate market volatility (create asset bubbles)
  - Asset prices inconsistently high relative to their fair or intrinsic value.
  - “Sleepy” traders tend to adopt more risky strategies, which are (or can be) exploited by more “alert” traders
  - This typically leads to lower earnings on average for the “sleepy” traders in markets characterized by both tired and alert traders
Collaborators

David Dickinson
Appalachian State University

Ryan Greenaway-McGrevy
University of Auckland
Dutch Tulip Bubble

- Asset prices that are inconsistently high relative to their fair or intrinsic value.
- In Netherlands, the prices of tulip bulbs increased by 5000% in three years (1634-1637)
South Sea Bubble, 1719-1720

The stock of the South Sea Company increased by 600% in one year (1719-1720), and lost more than that entire gain the following year.
Stock market crash of 1929

The American stock index, the Dow Jones Industrial Average lost over 90% of its value between 1929-1932.
The Internet (dotcom) bubble
We can study such asset bubbles in the laboratory

- Suppose we create a simple computerized market for the following asset.

- The asset has a life of one hour. Every four minutes the asset pays a dividend which is equally likely to be 0, 8, 28 and 60 cents, determined independently for each draw.

- At the end of the hour (15 rounds of trading), after the last dividend is paid, the asset has no value.
The (declining) fundamental value of this asset over time
Smith, Suchanek and Williams (1988)

- Construct a computerized market where the asset can be traded, with REAL money.

- **Traders start with cash, which earns interest plus an endowment of shares.**

- **Continuous double auction**
  - Buyers and sellers may submit/accept offers to/from the market at any time
  - If an offer is accepted, trade occurs at the offer price.
Typical price dynamics (Period 1)

Price

Time

Green vertical line: End of market period
Purple vertical line: Beginning of market period
Flat Horizontal lines: Fundamental value

Source: Noussair, Robin, and Ruffieux, 2001
Periods 1 and 2
Would you buy or sell now?

Price

Time

Green vertical line: End of market period
Purple vertical line: Beginning of market period
Flat Horizontal lines: Fundamental value
Periods 1 – 3
Would you buy or sell now?
How about now?

Price

Time

Green vertical line: End of market period
Purple vertical line: Beginning of market period
Flat Horizontal lines: Fundamental value
Price

Time

Green vertical line: End of market period
Purple vertical line: Beginning of market period
Flat Horizontal lines: Fundamental value
Price

Time

Green vertical line: End of market period
Purple vertical line: Beginning of market period
Flat Horizontal lines: Fundamental value
Price

Time

Green vertical line: End of market period
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Price

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Price

Time

Green vertical line: End of market period
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Flat Horizontal lines: Fundamental value
Price

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Purple vertical line: Beginning of market period
Flat Horizontal lines: Fundamental value
Price

Time

Green vertical line: End of market period
Purple vertical line: Beginning of market period
Flat Horizontal lines: Fundamental value

Bubble
Bubbles and Crashes

- Rather than tracking the fundamental value, a bubble and crash pattern is typically observed.

- The tendency for experimental markets to produce bubbles and crashes is one of the most celebrated (and replicated) results of experimental economics of the last 20 years.
So, what, if any, is the role of sleep (deprivation)?

- At least, *three* potential ways in which sleep deprivation affects decision making.
- Sleepiness likely to increase risk taking in gambles over gains (McKenna et al, 2007; Castillo et al, 2017)

- **Increased risk taking**
So, what, if any, is the role of sleep (deprivation)?

- Sleep loss disproportionately impacts *prefrontal and executive functions* (Horne, 1993; Muzur et al, 2002; Chee and Chuah, 2008), which, in turn, may impact *mentalizing during strategic interactions* (Hampton et al., 2010; Yoo et al, 2007)

- *Anticipation (Theory of Mind) harmed*
So, what, if any, is the role of sleep (deprivation)?

- Mild sleep restriction may increase optimism by accentuating the brain’s focus on positive reward anticipation (Venkatraman et al, 2011)

- Overconfidence increased
Experimental design

- Asset market experiment with traders geographically dispersed (global sessions)

- Standard *flat fundamental value* ($7) limit order market following design of Bostian et al (2005), and Bostian and Holt (2009), Holt et al (2017)
Experimental design

- **Low returns**: 10% interest on cash, average dividend draw of $0.70 ($0.40 or $1.00). Final period redemption at $7/share.

- **High returns**: 20% interest on cash, average dividend draw of $1.40 ($1.10 or $1.70). Final period redemption at $7/share.
Experimental design

- Groups of 10-11 (on average) each session.

- Both single location sessions ("local markets") as well as the two-location sessions ("global markets")

- Initial survey questions generate demographic and sleep measures, which include validated measure of morningness-eveningness.
Locations

Appalachian State University, NC, USA and University of Auckland
29 Sessions

GLOBAL MARKETS
(traders in two different locations)

<table>
<thead>
<tr>
<th>USA local time</th>
<th>New Zealand local time</th>
<th># Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noon</td>
<td>4:00am</td>
<td>2</td>
</tr>
<tr>
<td>4:00pm</td>
<td>8:00am</td>
<td>2</td>
</tr>
<tr>
<td>8:00pm</td>
<td>Noon</td>
<td>2</td>
</tr>
<tr>
<td>Midnight</td>
<td>4:00pm</td>
<td>2</td>
</tr>
<tr>
<td>4:00am</td>
<td>8:00pm</td>
<td>2</td>
</tr>
<tr>
<td>8:00am</td>
<td>Midnight</td>
<td>2</td>
</tr>
</tbody>
</table>

LOCAL MARKETS
(all traders in a single location)

<table>
<thead>
<tr>
<th>Location</th>
<th>Local Time</th>
<th># Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ</td>
<td>8:00pm</td>
<td>3</td>
</tr>
<tr>
<td>NZ</td>
<td>12:00noon</td>
<td>2</td>
</tr>
<tr>
<td>USA</td>
<td>Noon</td>
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<td>8:00pm</td>
<td>5</td>
</tr>
<tr>
<td>USA</td>
<td>4:00am</td>
<td>5</td>
</tr>
</tbody>
</table>

Sessions organized on Tuesdays, Wednesdays and Thursdays to avoid weekend sleep effects
Hypotheses

- **Hypothesis 1:** Global Markets will produce more significant asset market bubbles.

- **Hypothesis 2:** Traders at suboptimal times of day will hold more shares, as well as hold existing shares into later trading rounds.

- **Hypothesis 3:** Sleepy traders will earn less in global markets.
How to think about circadian-driven cognitive effect

MMlevel

Evening-Types
Intermediate-Types
Morning-Types

local time of day
Graph shows our approach to scoring subjects as HighMM=0 OR 1

Mismatch level, Based on self-report Alertness, (by chronotype)

\[ \text{MMlevel}=1 \text{ is most mismatched} \]

**Graph:**
- **Evening-Types**
- **Intermediate-Types**
- **Morning-Types**

**MMlevel** vs **local time of day (24=midnight)**
Graph shows our approach to scoring subjects as HighMM=0 OR 1

Mismatch level, Based on self-report Alertness, (by chronotype)

*MMlevel*=1 is most mismatched

MMlevel

- **Evening-Types**
- **Intermediate-Types**
- **Morning-Types**

local time of day (24=midnight)
Scoring validity (it’s valid)

- Self-reported sleepiness ratings (*Karolinska sleepiness scale*: 1=lowest, 9=highest sleepiness) elicited in the online survey administered immediately prior to asset market trading experiment (Ksleepy).

- Using data from all sessions, significantly higher Ksleepy scores among HighMM=1 subjects (n=51, avg Ksleepy=5.91) compared to the HighMM=0 subjects (n=155, avg Ksleepy=4.87)
  - \( p < 0.01 \) (nonparametric Mann-Whitney two-sample test of means)
Market outcomes and price movements
Local Markets, Low Returns

TREATMENT 1: Low Returns
LOCAL Markets

Share P (exp $)

Fundamental Share Value ($7)

Round within Treatment (note: order of T1 and T2 counterbalanced across sessions)
Global Markets, Low Returns

TREATMENT 1: Low Returns
GLOBAL Markets

Share P (exp $)

Fundamental Share Value ($7)

Round within Treatment (note: order of T1 and T2 counterbalanced across sessions)

AVG (Global)
Local Markets, High Returns

TREATMENT 2: High Returns

LOCAL Markets

Fundamental Share Value ($7)

Share P (exp $)

Round within Treatment (note: order of T1 and T2 counterbalanced across sessions)

AVG (Local)
Global Markets, High Returns

TREATMENT 2: High Returns
GLOBAL Markets

Round within Treatment (note: order of T1 and T2 counterbalanced across sessions)
Bubble measures

- **MaxPrice**: the maximum market clearing share price in the market (across all rounds);
- **Bubble Duration**: the longest run of market price increases across consecutive rounds;
- **Normalized average price deviation (NAV)**: the sum of the absolute deviations of market price from fundamental share value for each trading round;
- **Turnover**: transaction volume across all trading rounds relative to total available shares (see Corgnet et al, 2014).
\[ GINI = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} |x_i - x_j|}{2n \sum_{i=1}^{n} x_i} \]

where \( x_i \) is circadian mismatch level of trader \( i \); evaluates each market by its degree of circadian mismatch.

As the degree of circadian heterogeneity increases, market bubbles last longer.
Individual trader behaviour
Individual level behavior

Sleepy subjects hold more shares compared to alert subjects into later rounds

Sleepy subjects hold more shares in later rounds compared to earlier rounds.

In later rounds, sleepy subjects exhibit higher price bias (make higher bids) compared to alert subjects.
Share holdings across rounds (Global Sessions only)

Treatment #1: Low returns
- HighMM=...
- HighMM=...

Treatment #2: High Returns
- HighMM=...
- HighMM=...

Sleepy traders
Alert Traders
What happens to average individual earnings?

As the degree of circadian mismatch increases,

On average, sleepy traders earn approximately 20% to 30% less than alert traders.
Main take-away

- Global markets characterized by some traders operating at sub-optimal times of day; potentially important cognitive heterogeneity in traders in global markets.

- At the aggregate level, we found that this heterogeneity in circadian mismatch of traders resulted in **more pronounced asset price bubbles in our Global Markets** (most robustly, bubble duration is longer).
Main take-away

- “Sleepy” traders tended to hold more shares (the risky asset) in later rounds and also exhibited a greater degree of price bias.

- “Sleepy” traders on average earn less than alert traders and this effect is most pronounced in markets with a high degree of circadian heterogeneity, most notably in the case of global markets.
Limitations

- **Self selection** among our subjects? But real world markets (i.e., naturally occurring field data on traders) likely exhibit similar self-selection.

- Therefore, our results may be conservative estimates of the true suboptimal time-of-day impacts (but our estimates are or more interest to real world decision makers).

- Difficult to identify **which mechanism** may be of most important in our design (risk preference, anticipation, over-confidence).
Thank You!

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Questions?