Internet Spaceships are Serious Business: Econophysics of EVE Online

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Econophysics Presentation
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(Edited for the internet)
Overview of Talk

• What is EVE Online?
• Datasets used
• Power Laws
• Correlations
• Market Shocks
• Market Manipulation
• Further Research
What is EVE Online?

• Classified as a MMO
• Started in 2003
• “Sandbox” Gameplay
• Rich & Emergent Markets
  • Localized emergent market hubs
  • >10k individual items
  • 1-2M daily transactions
  • Commodities Market
Geography of EVE Online

- ~2,000 locally connected systems
- 4 Main Trade Hubs emerged in ~2005
- At Left: Zipf plot of sell order volume by rank. Jita (the top trade hub) has ~10x more volume then there would be via power law.
- In this project: focus on 5 trade hubs, primarily Jita
Mechanics of Trading

- Two Positions: “Asks” and “Bids”
- Asks: offer money and wait for players to sell to you.
- Bids: offer items and wait for players to buy from you.
- Any item is always sold/bought with the best bidder.
- Transaction Tax:
  - 0.75% to place an order
  - 0.80% to complete a transaction (for both parties)
- Money: ISK (InterStellar Kredit OR Icelandic Krona)
Data Used

• Publicly Available data from Third-Party Website:
  • https://eve-central.com/
• Cache Scraping to collect data from players who offer to help
  • Incomplete data set!
• Data from 2006 – Present
  • Stored as a data dump; highly uncompressed
  • ~300 Mb/day, or 110 GB/year
• First thing: Download & Compress data
  • Select only orders from 5 main trade hubs
  • Select only top ~1,000 most popular items
  • Compress data from all orders to the Best order, and the total order volume
• Compressed to ~1.5GB for 300 days of data
Data Used (Continued)

• Data points are independent vectors of:
  (ItemID, Location, Buy Price, Buy Volume, Sell Price, Sell Volume)

• Convert data into a time series:
  • Create time boxes, fill all empty boxes with nearest left filled neighbor
  • Multiple points per box are averaged.
Example Data

- Hourly-Averaged data for “Mexallon” (Equivalent to Steel or similar; a basic building material)
- 54,773 Data points in Jita (7.6 per Hour)
First Result!

- Prices tend to settle to round Numbers, aka 810,000,000.00
- Insight on mentality of players?
- Market Inefficiencies!
Further Exemplified: “PLEX Inflation”

- December 2014: the PLEX speculation bubble
- Prices rose from 500m in 2012 to >800m in 2014
- Sell Prices touched 1,000m, which caused the bubble to burst, just because of the number.
Is this system similar to real Markets?

- Power Law Returns?
- Efficient Market Hypothesis?
- Cross-Market Correlations?
- Trade-Hub Emergence?
- Cross-Item Correlations?
- Market Shocks?
- How can I make a profit?
Power Law Returns

• Looking at 24h returns for different items
• On right: “Basic Minerals” market group; Equivalent to basic commodity prices (steel, wheat, etc)
• Recover a power law as is expected
• “Tritanium” had an anomalous event in 12/14 which messed up normalization
• Less active items are anomalous around 0 returns
Efficient Market Hypothesis

- “There are no chances for Arbitrage in the system”
  - All autocorrelations are zero for non-zero time shifts
  - Inter-item correlations are the same, or small
Autocorrelations of Returns

- 48 Hour returns with 1 hour shift means there is some “blurring”
- Daily timescales are “Natural” for this system; the market is normally slow.
Does this violate the Efficient Market Hypothesis?

- NO: there is a Transaction Tax which allows for small correlations!
- Suppose you knew that an item was going to increase in value in the next 48h. How do you profit?

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Purchase at Low Value</td>
<td>-$800,000,000.00</td>
</tr>
<tr>
<td>Transaction Tax (1.7%)</td>
<td>-$13,600,000.00</td>
</tr>
<tr>
<td>Sell 48h later (+2.0%)</td>
<td>+$816,000,000.00</td>
</tr>
<tr>
<td>Transaction Tax (1.7%)</td>
<td>-$13,872,000.00</td>
</tr>
<tr>
<td>Total Profit</td>
<td>-$11,472,000.00</td>
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- Most fast Fluctuations are below transaction tax threshold: Not scale free!
Cross-Market Correlations

• Are there “Leader” and “Follower” markets?
  • 5 main trade hubs! Cross-correlate returns for time series!
  • Jita (the largest trade hub) is consistently the leader of price changes
Market Shocks and Speculation

• Sometimes the game developers announce changes to the game
  • Equivalent to the Federal reserve changing interest rates, or companies announcing new products.
  • Announcements range from balancing ship classes to modifying mineral manufacturing ratios.

• Prices can rapidly change to settle on a new optimal value, on timescales of hours!

• Markets can be small enough to allow for manipulation by players
Market shocks are common

- “Invention” Changes on 11/1/2014 (Some results below)
- Proposed Mineral changes on 4/1/2015: Some prices **double**
- Anti-Botting Mechanism late 2014: Partially responsible for PLEX crash
Market Manipulation

• The basics are simple:
  • Buy a large volume of an item to push up the price
  • Re-list all purchased items at the higher price
  • Sell all items at a higher price for a profit
  • Hope you sell everything before prices return to normal!

• How does a Transaction Tax effect Manipulation?
• How can I use this information to make a profit?
Some Basics...

- Volume Response
- Time Response
- Definitions:

\[ \gamma \] – Price-Volume relationship [ Percent per Item ]
\[ \tau \] – Characteristic System Time [ Time ]
\[ V \] – Volume [ Items per Time ]
\[ T \] – Transaction Tax [ Percent ]
\[ N_c \] – Characteristic Itemscale: \( \tau V \)

(Board Work goes here)

Conclusion: Transaction tax creates stability and reduced volatility in the system: There is a “Threshold” set by transaction tax which a manipulation must be above.
Continued...

Taking the $T \to 0$ Limit:
1) $\gamma \to 0$ means “Large Market”: prices don’t change
2) $\tau \to 0$: “Efficient Market”: prices quickly re-stabilize
3) $N/N_c \to 0$: “Large Market” - one person can’t influence

\[ T < \gamma N(1 - \exp(N/N_c)) \]

Conclusion: Transaction tax creates stability and reduced volatility in the system: There is a “Threshold” set by transaction tax which a manipulation must be above.
More things to explore!

• Trade Hub Emergence
• System response to shocks
• Price-Impact Function
• Market Manipulation
• Material-Product Correlations
• More impacts of taxation
• Exploiting Market Inefficiencies!

• How can I make a profit?
Thank You!

- Eðvald I. Gíslason, Analyst CCP Games
- Antonio, Chester & Dr. Stanley
- http://www.eve-central.com
- http://www.eve-markets.com
- http://imgur.com/gallery/jOfk1
- All art used is from CCP Games