

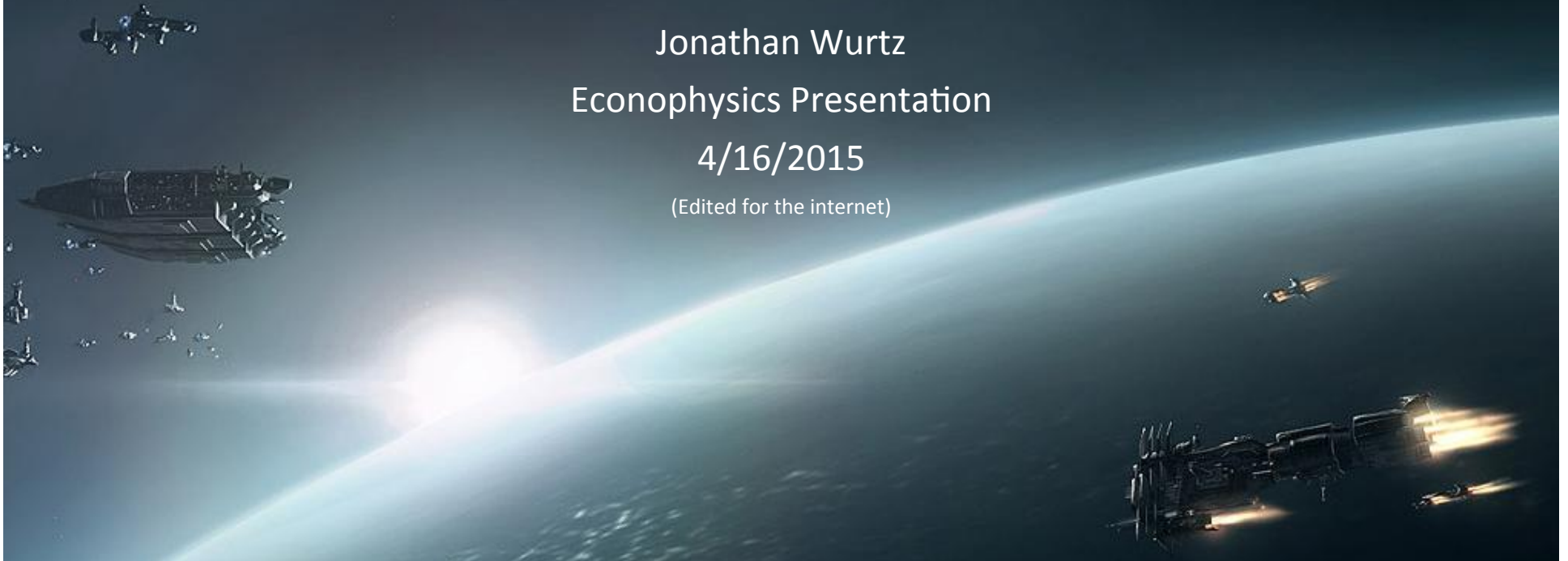
# Internet Spaceships are Serious Business: Econophysics of EVE Online

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Econophysics Presentation

4/16/2015

(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

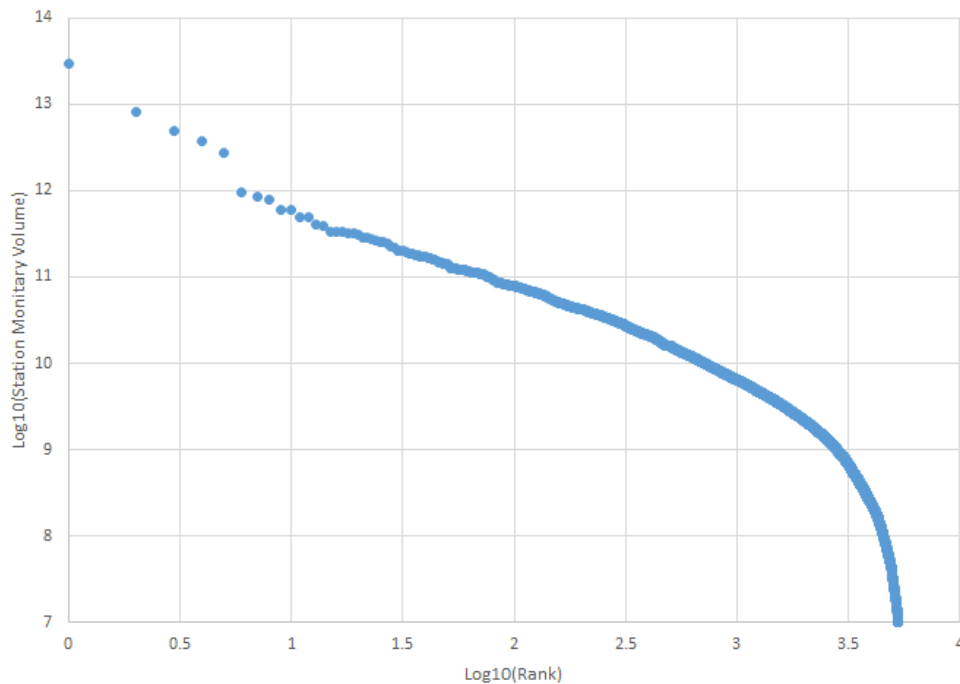


# Geography of EVE Online

Amarr Dodixie Jita YOU ARE HERE  
Hek  
Rens

Total Sell order Volume per station

Source: <http://eve-marketdata.com/station.php?step=Rank>



- ~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 than 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)

**The Forge Regional Market**

Search term:  Search

- Ammunition & Charges
- Apparel
- Blueprints
- Drones
- Implants & Boosters
- Manufacture & Research
- Pilot's Services
  - 30 Day Pilot's License Extension (PLEX)**
  - Pilot's Services
- Planetary Infrastructure
- Reactions
- Ship Equipment
- Ship Modifications
- Ships
- Skills
- Special Edition Assets
- Structures
- Trade Goods

**Market Data** Price History

**Sellers**

Jumps	Quantity	Price	Location	Expires in
Station	23	808.899.999.99	Jita IV - Moon 4 - Caldari Navy Assembly Plant	13d 23h 28m 11s
Station	1	808.988.476.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 23h 58m 7s
Station	1	808.999.998.99	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 23h 16m 44s
Station	1	809.000.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 22h 37m 59s
Station	2	809.314.000.00	Urlen VII - Moon 6 - Hyasgoda Corporation Refinery	89d 20h 12m 15s
Station	1	809.314.000.00	Perimeter II - Moon 1 - Caldari Navy Assembly Plant	89d 20h 12m 43s
Station	1	809.314.000.00	New Caldari II (Matias) - Kaalakiota Corporation Factory	89d 20h 12m 57s
Station	100	809.314.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 22h 48m 35s
Station	12	809.314.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 20h 21m 35s
Station	1	809.316.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 13h 23m 3s
Station	1	809.317.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 22h 31m 48s
Station	4	809.318.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 13h 21m 25s
Station	5	809.320.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 13h 19m 37s
Station	5	809.330.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 13h 17m 15s
Station	4	809.339.999.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 13h 7m 22s
Station	1	809.340.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 12h 57m 59s
Station	4	809.390.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 12h 54m 59s
Station	2	809.409.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 12h 54m 19s
Station	4	809.410.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 12h 53m 13s
Station	5	809.449.000.00	Tourlainas II - Spacelane Patrol Assembly Plant	89d 7h 30m 54s
Station	2	809.449.000.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 12h 48m 16s
Station	1	809.799.979.00	Jita IV - Moon 4 - Caldari Navy Assembly Plant	89d 9h 56m 15s

**Buyers**

Jumps	Quantity	Price	Location	Range	Min	Expires in
Station	1	795.261.000.00 ISK	Perimeter IX - Caldari Constructions Production Plant	Station	1	26d 2h 10m 0s
Station	1	795.001.555.00 ISK	Jita IV - Moon 4 - Caldari Navy Assembly Plant	Station	1	89d 23h 58m 41s
Station	1	795.000.000.00 ISK	Jita IV - Moon 4 - Caldari Navy Assembly Plant	Station	1	89d 23h 48m 13s
Station	3	793.482.000.01 ISK	Jita IV - Moon 4 - Caldari Navy Assembly Plant	Station	1	23h 55m 23s
Station	19	793.475.000.00 ISK	Jita IV - Moon 4 - Caldari Navy Assembly Plant	Station	1	89d 23h 53m 23s
Station	1	793.466.987.01 ISK	Jita IV - Moon 4 - Caldari Navy Assembly Plant	Station	1	89d 23h 47m 38s
Station	2	793.465.000.00 ISK	Jita IV - Moon 4 - Caldari Navy Assembly Plant	Station	1	23h 46m 5s

Export to File Place Buy Order

# 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

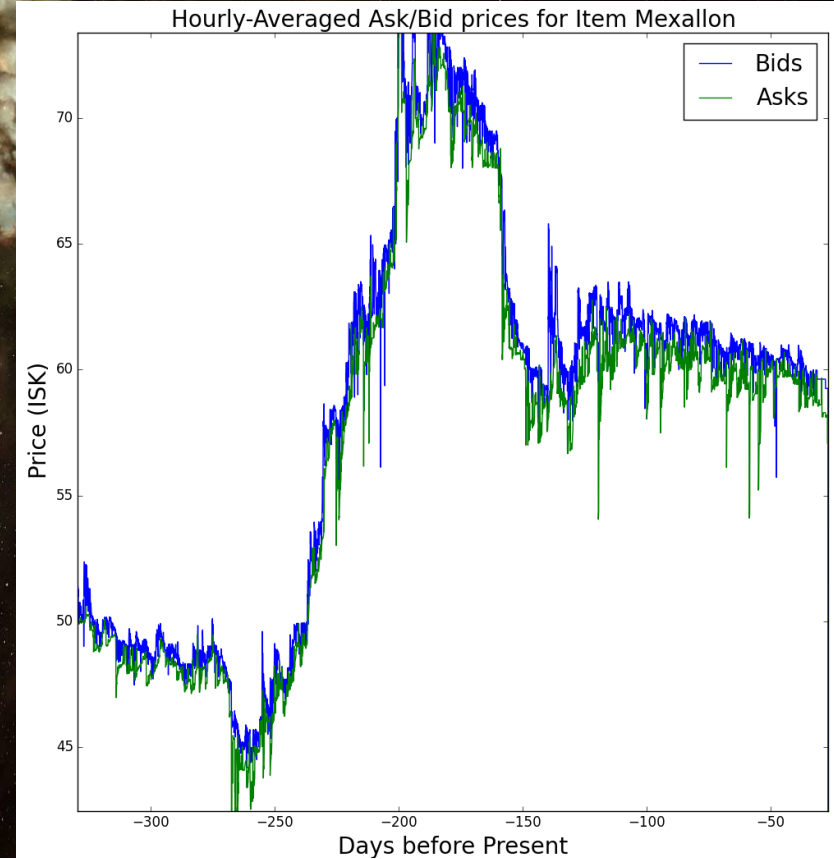
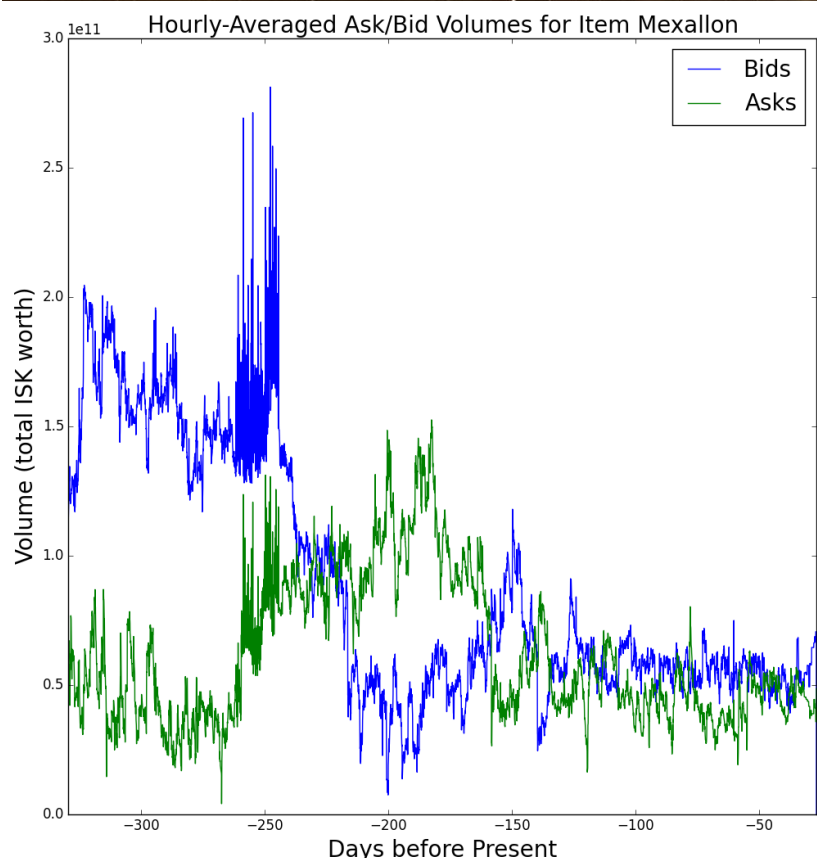
# Data Used (Continued)

- 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

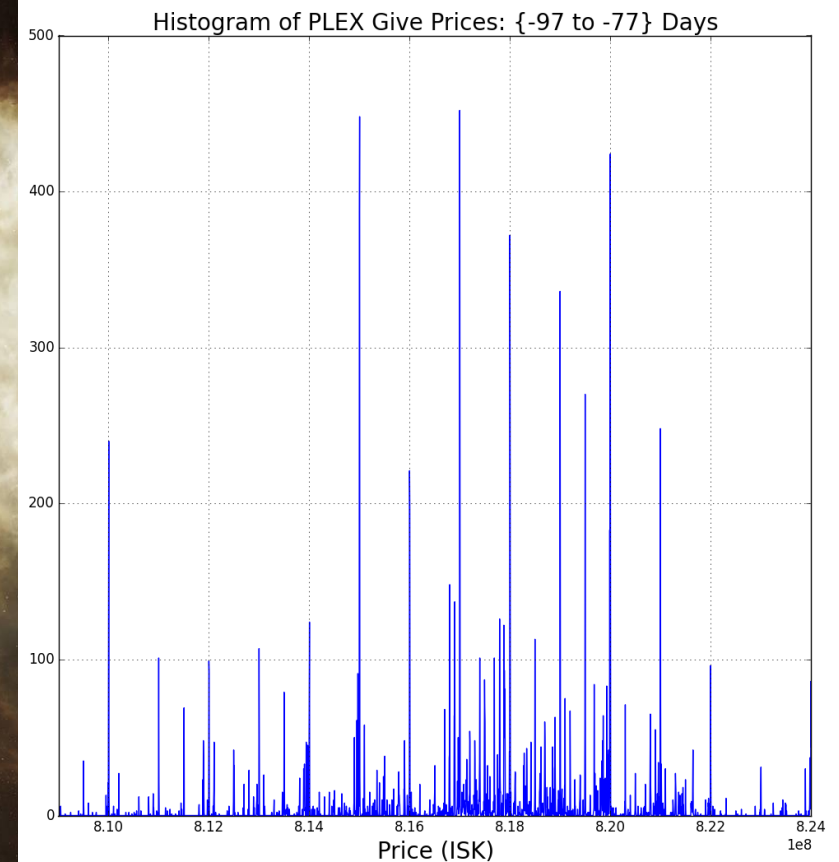
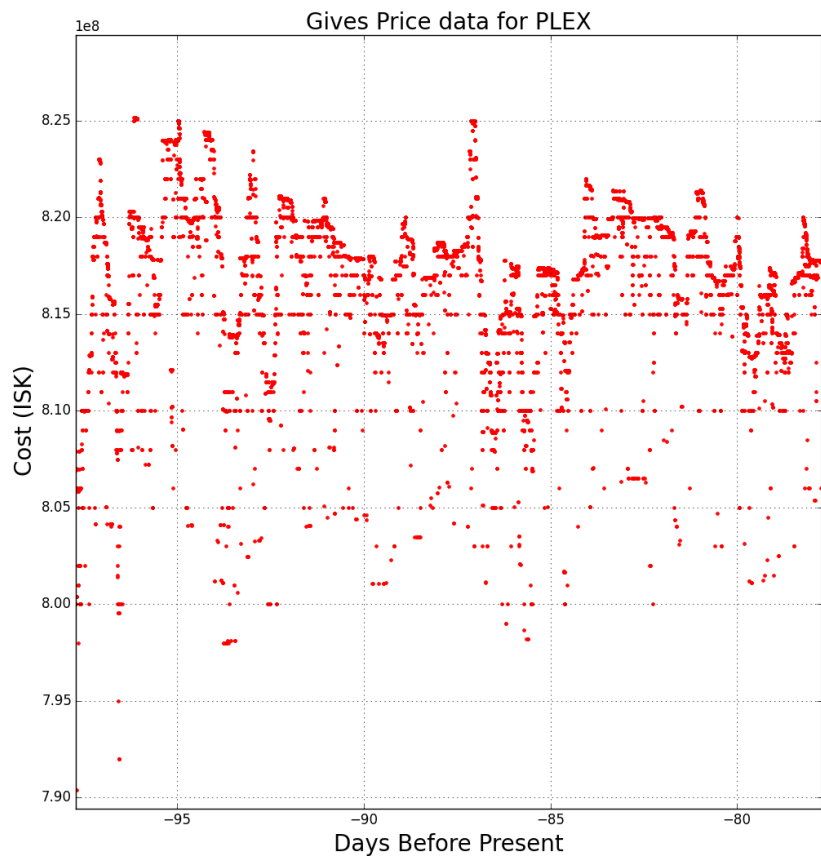
- Hourly-Averaged data for “Mexallon” (Equivalent to Steel or similar; a basic building material)
- 54,773 Data points in Jita (7.6 per Hour)





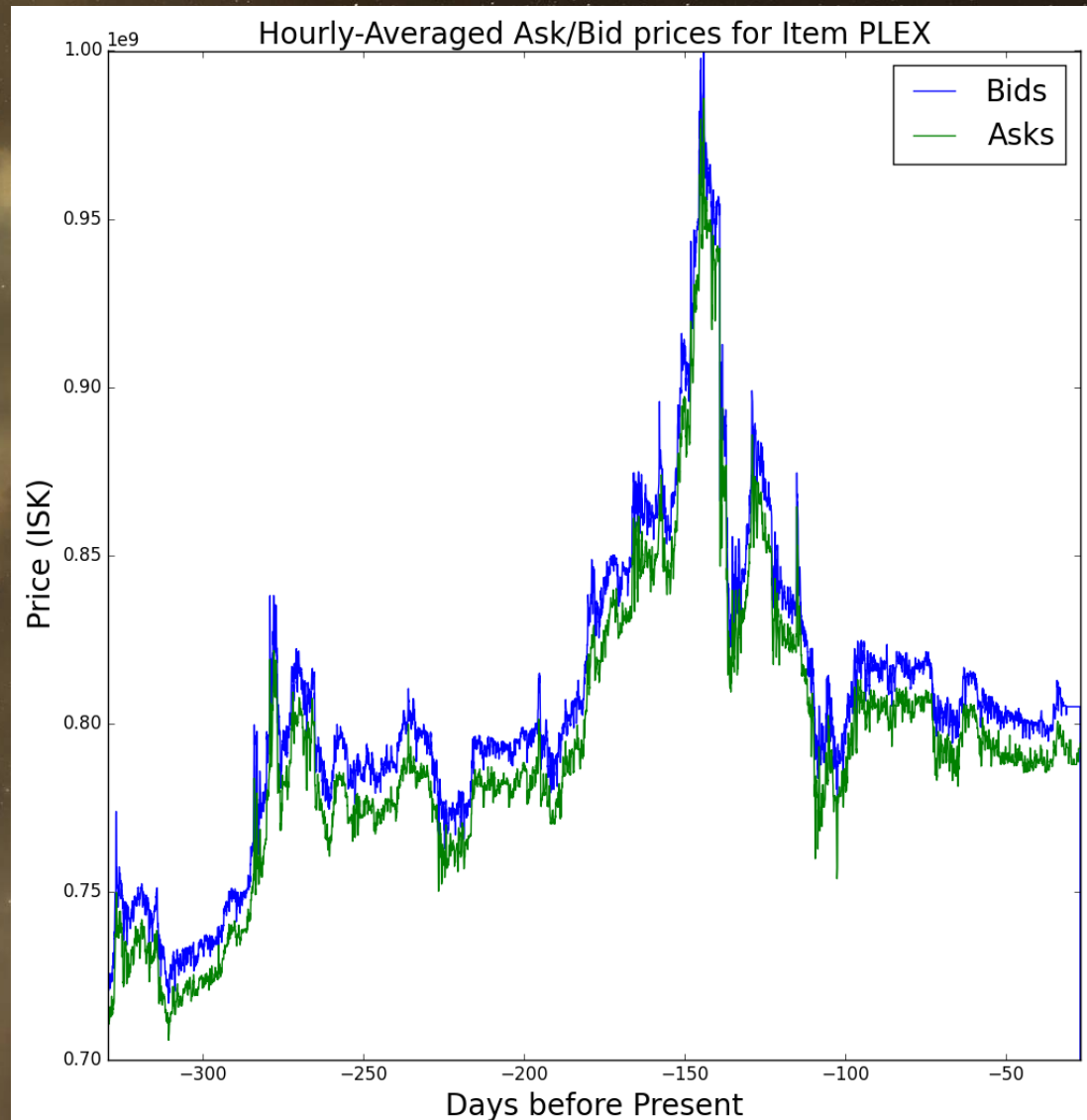
# First Result!

- 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.**

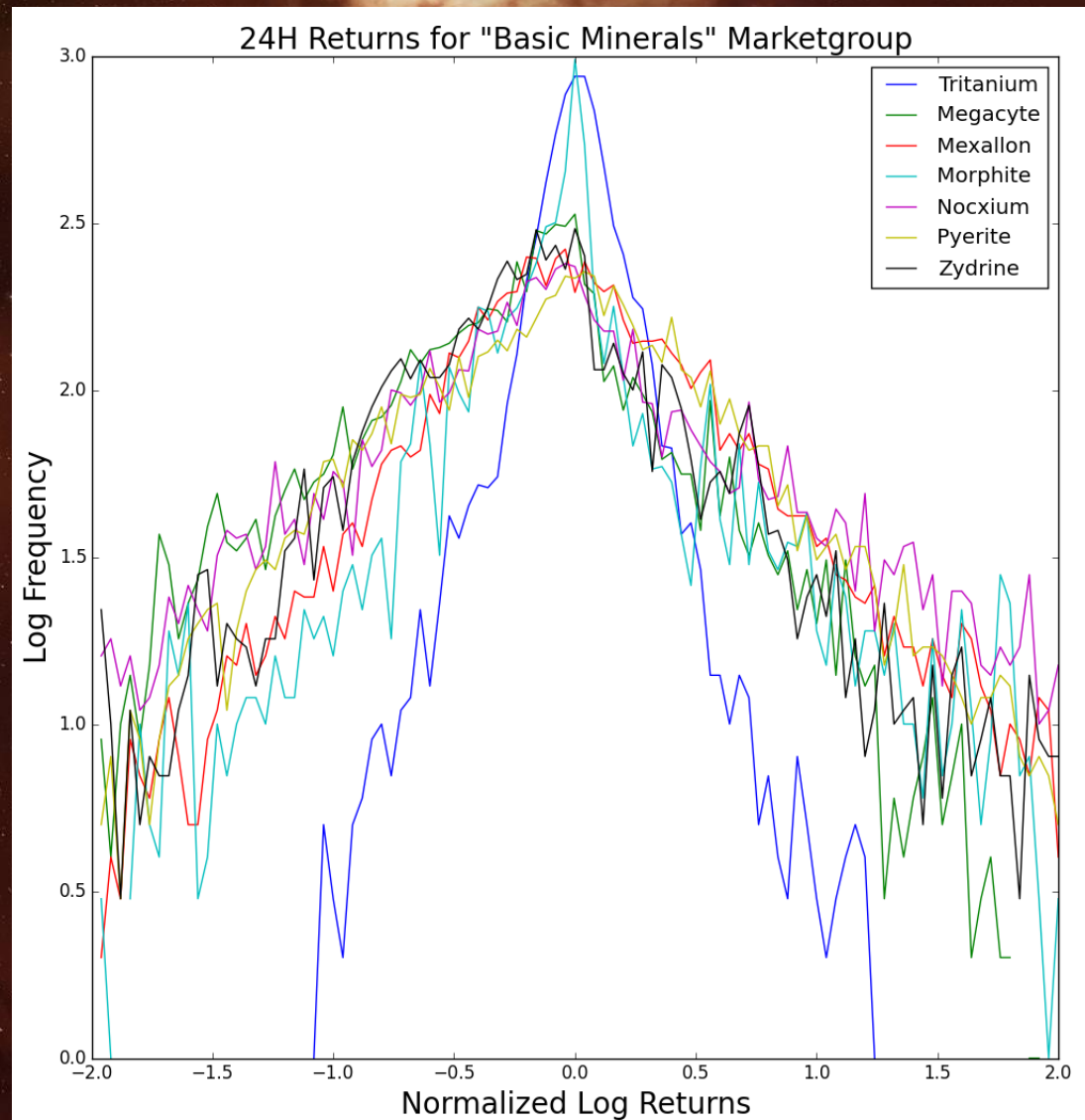


# Is this system similar to real Markets?

- 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

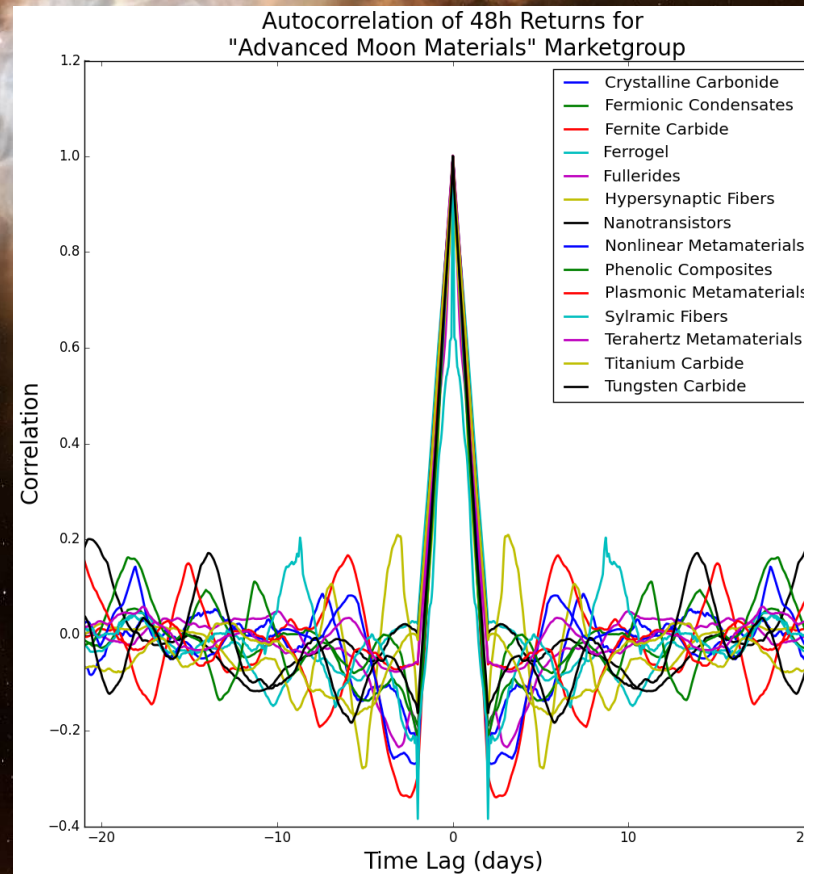
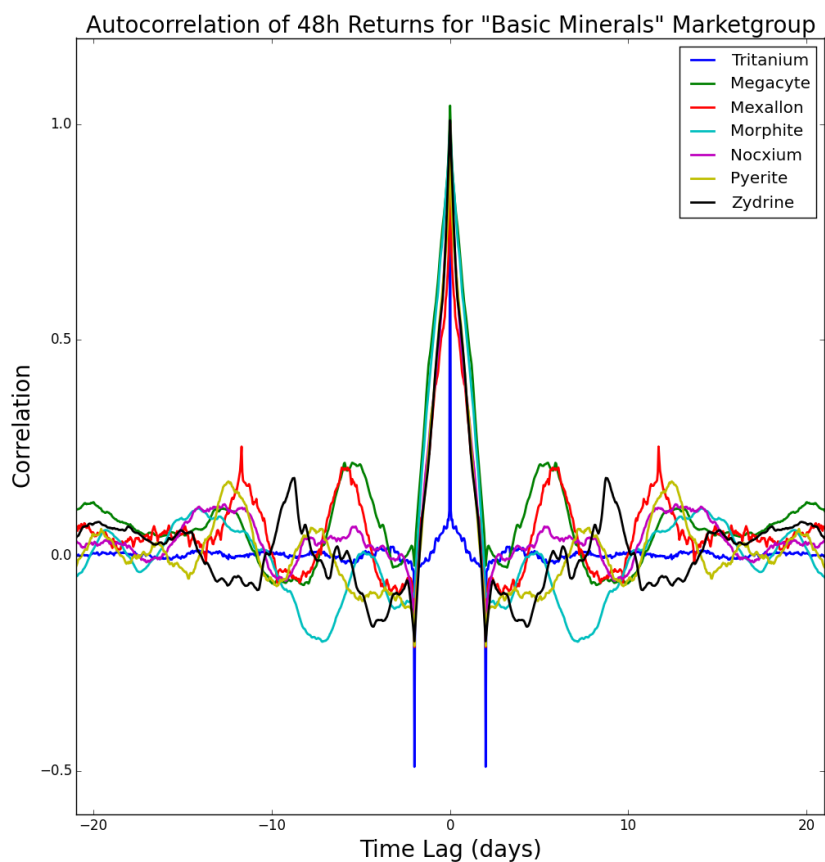


# Efficient Market Hypothesis

- “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.

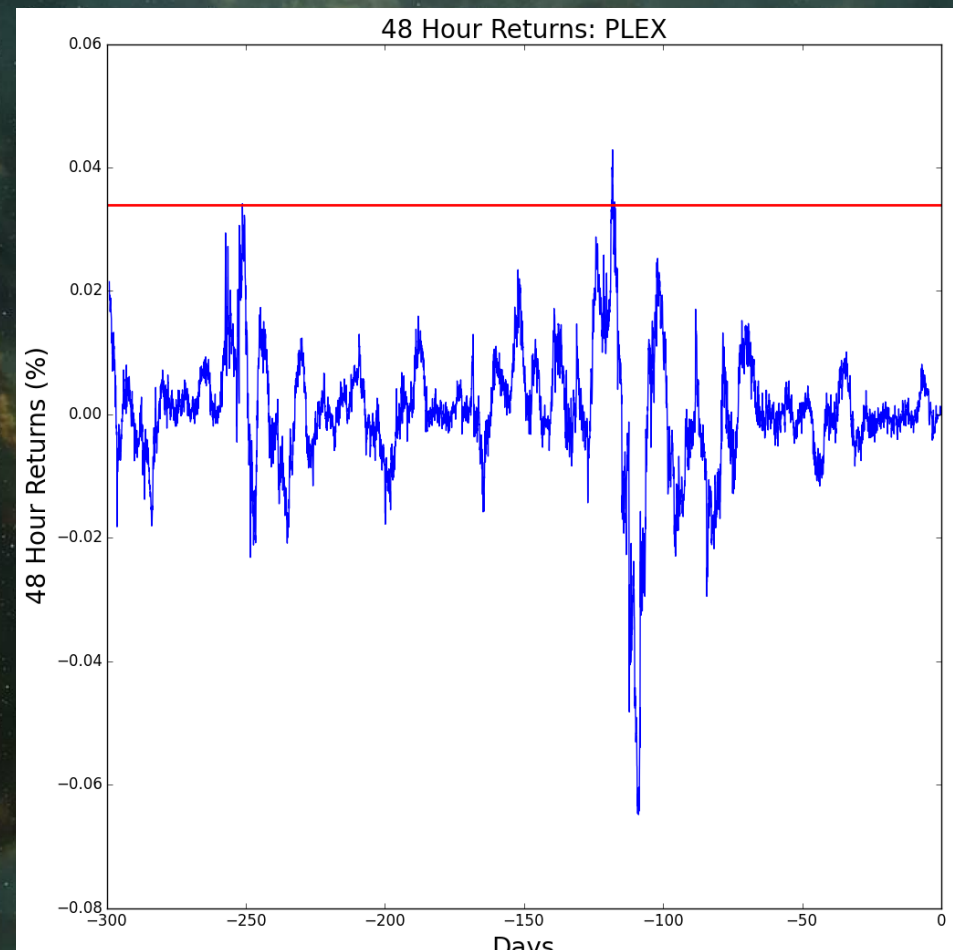


## Does this violate the Efficient Market Hypothesis ?

- 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?

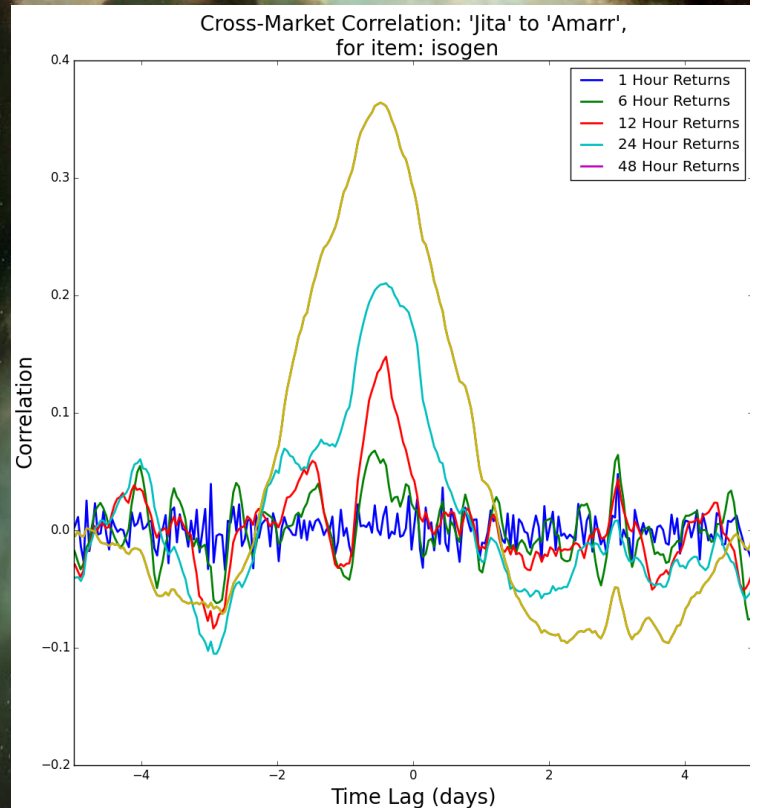
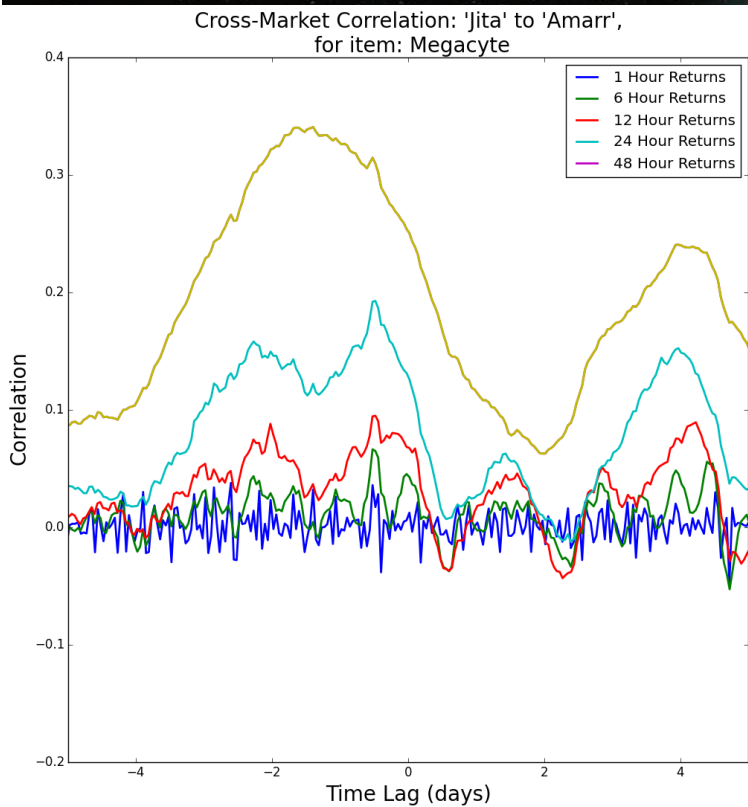
Purchase at Low Value	-\$800,000,000.00
Transaction Tax (1.7%)	-\$13,600,000.00
Sell 48h later (+2.0%)	+\$816,000,000.00
Transaction Tax (1.7%)	-\$13,872,000.00
<b>Total Profit</b>	<b>-\$11,472,000.00</b>

- Most fast Fluctuations are below transaction tax threshold: Not scale free!



# Cross-Market Correlations

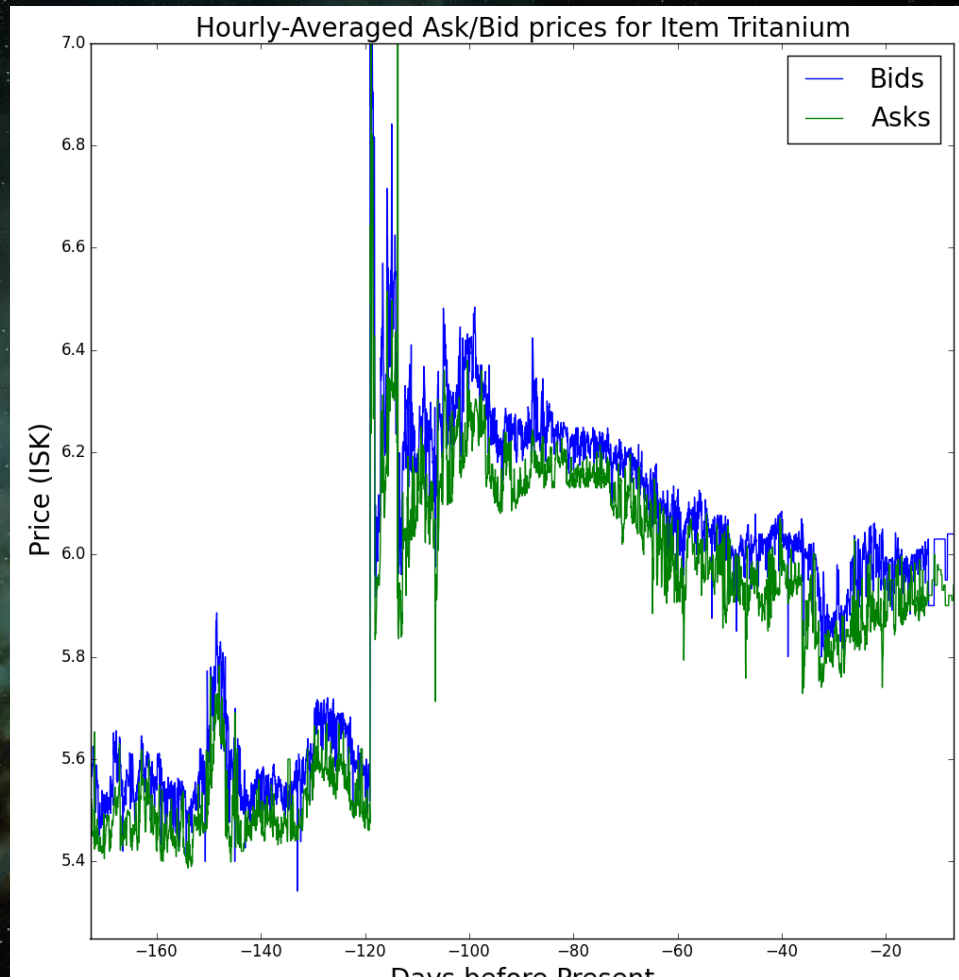
- Are there “Leader” and “Follower” markets?
  - 5 main trade hubs! Cross-correlate returns for time series!
- Jita (the largest trade hub) is consistently the leader of price changes





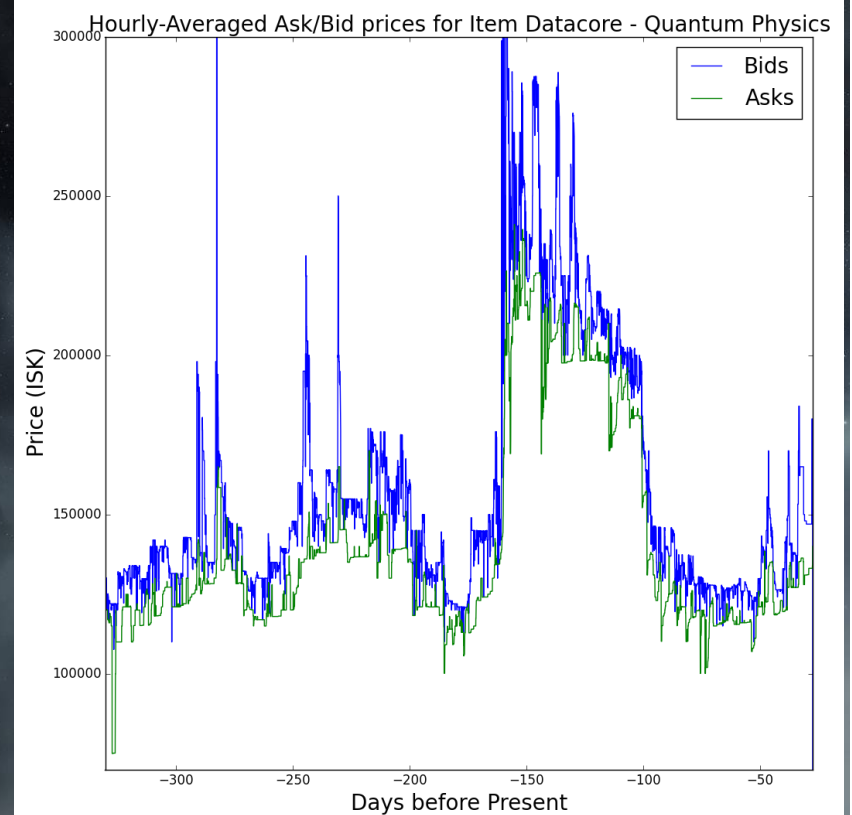
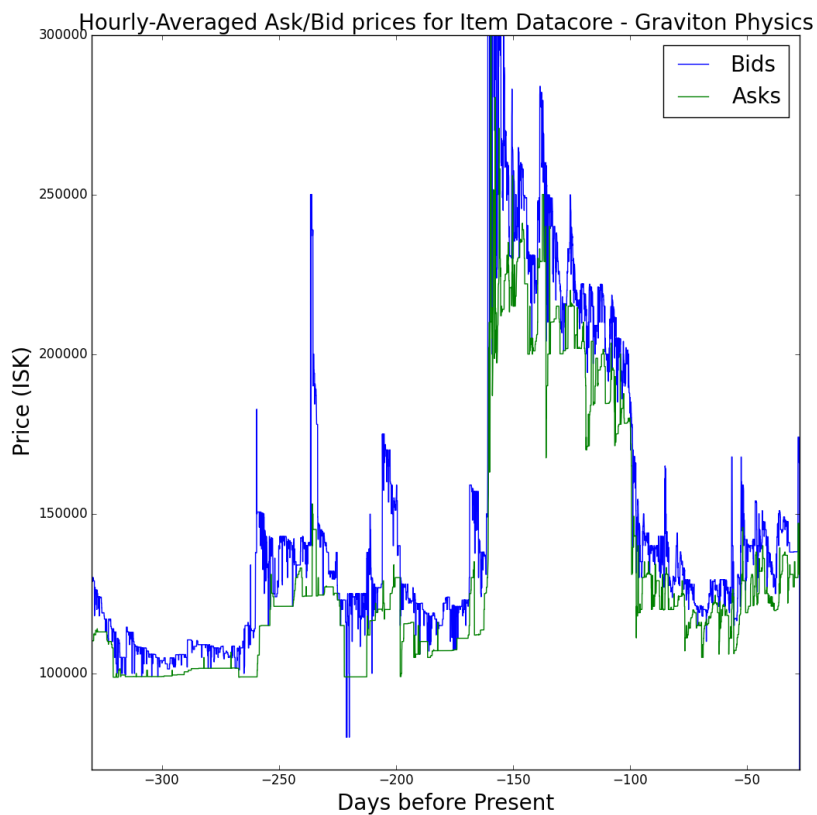
# Market Shocks and Speculation

- 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  $T \rightarrow 0$  Limit:**

- 1)  $\gamma \rightarrow 0$  means “Large Market”: prices don’t change
- 2)  $\tau \rightarrow 0$ : “Efficient Market”: prices quickly re-stabilize
- 3)  $N/N_c \rightarrow 0$ : “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