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The Effect of Predatory Trading on the Stock Market

Big Picture

Many people in the United States, and in the world, have some stake in the stock market. Whether it be for retirement, school, or something else entirely, people want to have a place to invest their hard-earned money. Additionally, many use the stock market as a way to measure the health of the economy. Recently, indexes such as DOW Jones have been performing well, giving an indication of a recovering economy from the wake of the recession of 2009. However, while the stock market may be growing, many Americans don't feel as if the economy is actually growing[1].

Liquidity, or activity, in the market is often looked at as a sign of how healthy the market is. Liquidity has increased recently, corresponding with an increase in predatory trading. Predatory high frequency traders look to take advantage of latency in the market, which is caused by superior technology and closer geographic location to stock exchanges, by gaining information about large trades before they take place. With this information, predatory traders can rush ahead to purchase that stock from the market before the buyer can purchase the stock. Then, the predatory traders can either immediately turn around and sell it to the buyer at a slightly higher price, or wait a few more seconds to maybe drive the price up even more[2]. This results in the predatory traders making almost riskless profit without actually contributing anything to the market, as they will only ever own the stock for a few seconds. While this practice only skims off of the trades, making small

[1] "Gallup Daily: US Economic Outlook." Gallop.
[2] Lewis, Michael. *Flash Boys*. New York: W.W. Norton & Company, 2014, page 76.

profits each time, it still takes money away from ordinary investors, in a way that certainly seems like Wall Street insiders subtly gaming the system[3].

What Can Be Learned

This model does not simulate all of the complexities of the stock market. However, it is meant to show the effect that predatory trading has on the market through a simplified stock market. The original driving question for the model is: How harmful are predatory traders for the general population and for the market itself? And should banks and firms be taking more steps to protect their investors?

In terms of what can be learned from the model, first is how predatory trading affects liquidity in the market. This can affirm that these practices are driving liquidity up, and as it is highly expected, this measure is more of a validation observation. Next, and more importantly, one can learn about how predatory trading affects the average wealth of normal investors, how it affects total wealth, and how risk-free the practice is for predatory traders.

Motivation/Rationale

While the market should be a free market in our capitalist society, the government should have some restrictions to protect ordinary investors from those looking to cheat the system. While predatory high frequency trading remains legal, it is a questionable practice, and if shown to be harmful, should be regulated. As traders in a stock market act like agents, ABM is a good way to attempt to model the effect of predatory traders and show how harmful the practice of predatory trading is.

[3] Drum, Kevin. "In Defense of "Flash Boys"" Mother Jones. April 7, 2014.

Rules and Model Implementation

The model consists of two breeds of turtles. One is the standard trader (referred to as just trader), and the other is the predatory trader. Both kinds of traders have wealth, which is a number that represents the amount of wealth held outside of stock they have. Traders then have stock, which is a number that represents the amount of money the trader owns in stock. Traders are initialized with a random amount of stock distributed around 30% of their total wealth. The traders also own wps, which is their wealth plus their stock, or the total wealth of the traders. Traders own bid-ask, which reflects how much money they are either bidding to buy the stock for, or how much money they are offering to sell the stock for. This number is taken as a random number from a normal distribution spread around the random amount of stock to be transferred. The standard deviation of the normal distribution is determined by the bid-ask-spread slider exposed to the user. 1 point is equivalent to .01%, so a 100 point spread would mean a standard deviation of 1% of the stock amount when calculating the random distribution. Finally, traders own gain, which is a number that keeps track of how much money they've made since their last stock purchase. A positive number means the stock has appreciated, while a negative number means the trader has lost money. This is kept track of by subtracting the initial amount of stock, appreciating (or depreciating) the stock, and then adding that new value to gain. Next, there are a few system parameters, such as the number of people in the model, the average initial wealth of those people, and a switch for including or leaving out predatory traders from the model. If the switch for including predatory traders is in the on position, then the model adds amount-predatory-traders percentage predatory traders out of the number-people value, with the remaining number being traders.

The stock market is modeled with one value per trader that indicates the worth of their stock. However, stock appreciation is calculated as a trader procedure – in other words, a random-normal distribution value is selected for each trader's stock variable. The standard deviation of this distribution is the current (as of writing) volatility of the S&P 500, or 2%[4]. This, in essence, simulates a bunch of different stock on the market as each trader's stock appreciates differently. This was decided to be better than a list of a few stocks or just one stock that appreciates uniformly because it more accurately models the complex variation in the appreciation and depreciation of stocks in the market. Just having a few pre-defined stocks would not allow for quite as fine of a variation. While this means that there are no specific stocks that are more likely to do well than others, this was acceptable as that aspect of the market is not the main focus of the model.

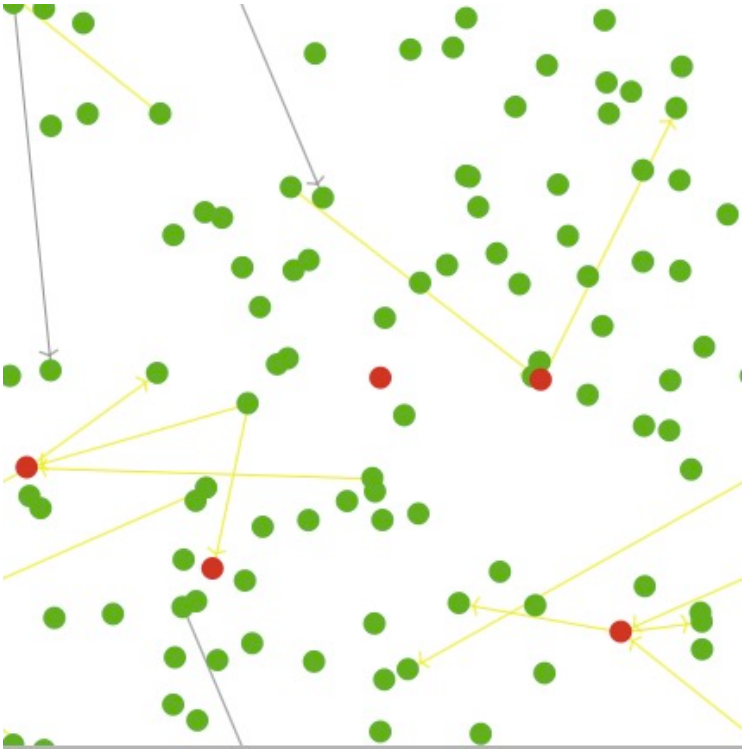

Figure 1: A sample visualization from the model. Red dots indicate predatory traders

[4] "Volatility S&P 500". Yahoo! Finance, 2016.

Trader rules followed in a single tick:

- If I have any wealth, I consider buying stock
- If I decide to buy stock, I decide the amount of stock I want to buy, and the price at which I am willing to buy it
- Try to find another trader that has that amount of stock, and have that trader set the price at which they are willing to sell
- If I am the seller, I only sell if I have already made money on the stock or lost at least 10%, and if the bid price is higher than my ask price, I will sell the stock
- If a trade takes place, create a grey link between the two traders

Predatory Trader rules followed in a single tick:

- If the amount of stock being traded is high enough, I will hijack the trade, gaining the spread between the bid and the ask price as profit, and allowing the trade to be completed
- If I hijack a trade, create two yellow links, one between the buyer and me, and one between the seller and me

Measures:

1. Average wealth for both trader kinds
2. Average stock
3. Average wealth for traders
4. Average wealth for predatory traders
5. Total wealth
6. Trades (and trades/day)

Analysis

The main analysis performed on the model is behavior space simulations. As the main objective of the model was the effect of predatory trading, the predatory-trading? boolean variable was the only one changed, with 50 simulations of 2500 ticks (approximately 10 years of trading days) performed for each value of the variable. Then, various measures were examined for trends, both for verification with reference patterns and real world data, and to find an emergent pattern in the model.

The model can be verified with several reference patterns observed in the world. First, is the pattern of agents in an economy quickly separating out into a few very wealthy and many moderate to poor agents, a skewed right distribution. When running the model, this pattern is readily apparent.

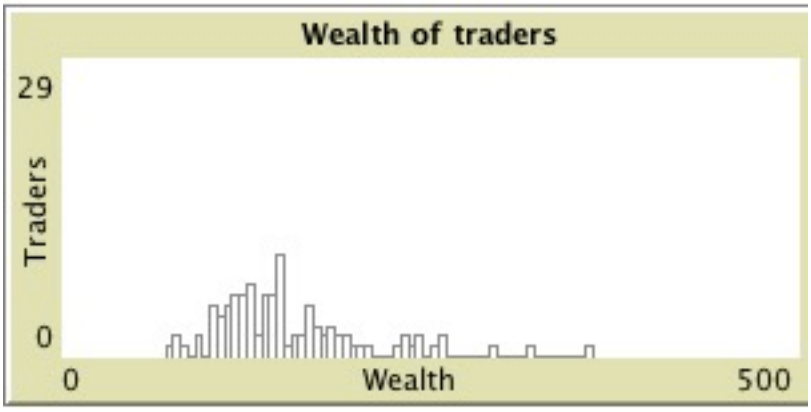

Figure 2: Skewed right distribution of wealth among traders

Next, predatory high frequency traders are very often thought to increase liquidity in the market. This, in fact, is one of the main arguments as to why the practice is beneficial to the market and shouldn't be regulated. Therefore, the model should reflect an increase in the rate of trades, which it is successful in doing as well.

	Regular Market	Market with Predatory Trading	Change
Trades/day	8.20	10.81	+31.86%

Figure 3: Table of rate of trades for regular market vs market with predatory trading

The numbers above are averages of 20 behavior space simulations for 10 years of trading for both a market absent of predatory trading, and a market that includes predatory traders. There is a significant increase in the number of trades, as shown in the graph below.

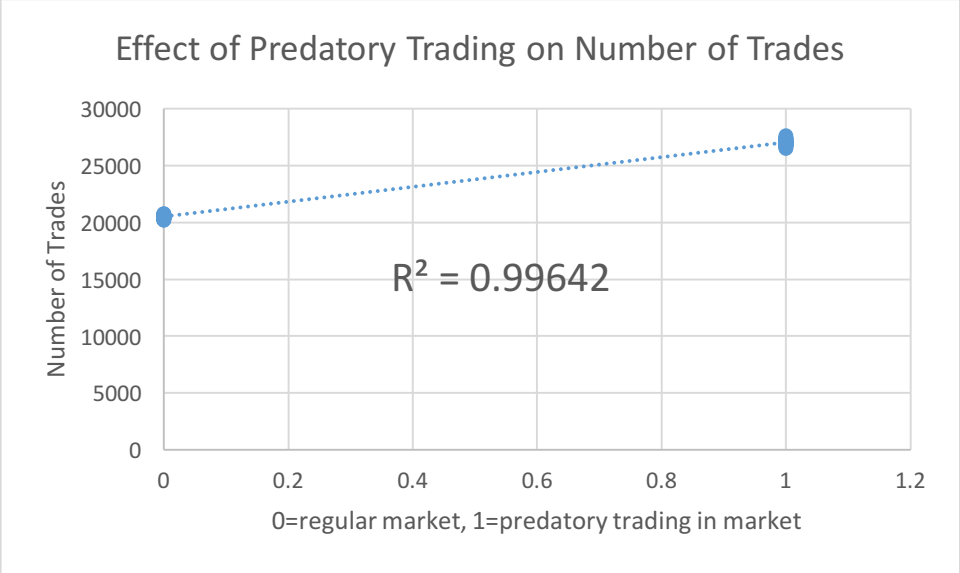

Figure 4: Graph showing total number of trades per simulation with predatory trading binary variable

These two results show the model to be accurate to empirical findings for a stock market, and help to improve the model's legitimacy as an accurate representation of the market. However, neither of the results say much about the effect of predatory traders on the market. There are two main measures that can detail this effect: average wealth of regular traders, and total wealth in the market

Average Wealth of Regular Traders

While this measure isn't representative of the entire market, it is representative of the majority of people trading. If the majority of people in the market are being negatively affected, that's a pretty good indication that something should be changed. The average scores from the behavior space experiment of average trader wealth are shown below:

	Regular Market	Market with Predatory Trading
Average wealth of traders	179.35	160.78

Figure 5: chart of average wealth of traders in behavior space experiment

This is a fairly large difference between the two. In terms of average wealth of traders, there is about a 10% difference when predatory trading is introduced into the market. In addition, as initial wealth was set to 150, the difference in the increases in wealth is a huge 63%.

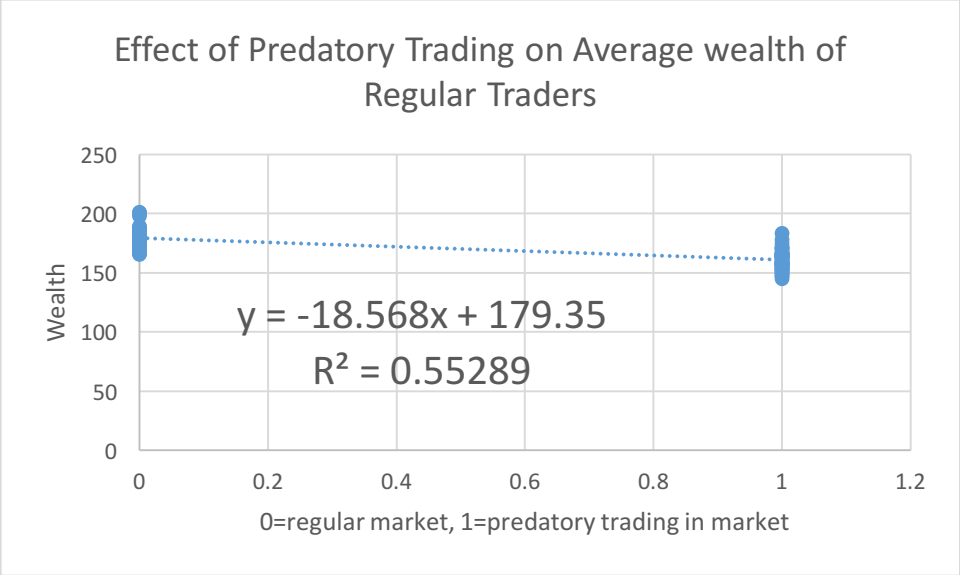

Figure 6: Graph of individual data from behavior space with regression line

The graph above depicts the individual data points of total wealth from each behavior space run, with a 0 representing no predatory trading and 1 representing otherwise. It also shows an indirect relationship between average wealth and the existence of predatory

trading in the market with a relatively large R-squared value. This is clearly detrimental to ordinary traders and investors, as they are losing out on a pretty large portion of wealth growth to the predatory traders. Many argue that since in terms of the average wealth of a trader, predatory trading seems to just skim off small amounts, it really isn't too harmful[5]. However, these numbers indicate that the wealth accumulated by predatory traders turns out to be at the expense of a pretty large percentage of regular traders' wealth. Even if the predatory trading effect is viewed as a skim-off of wealth, it adds up eventually.

Total Wealth in the Market

The ultimate measure for whether predatory trading hurts the market as a whole is the total wealth in the market. It is pretty clear that any practice that decreases the amount of wealth in the market as opposed to operating without that practice being put into place is detrimental. Behavior space results show a difference of about 5% in total wealth between the normal market and the market with predatory trading.

	Regular Market	Market with Predatory Trading
Total Wealth	17935	16950

Figure 7: chart of total wealth of the market in behavior space experiment

[5] Drum, Kevin.

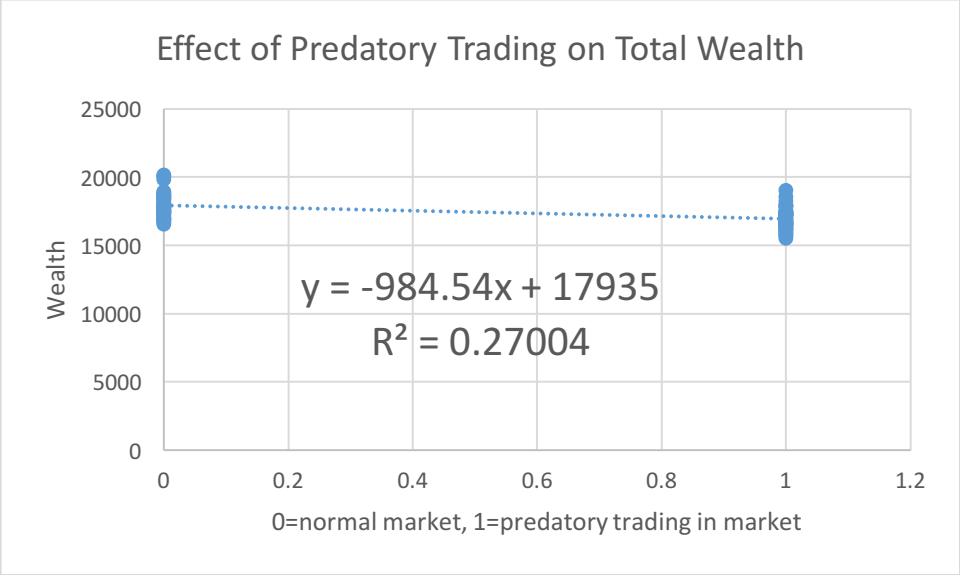

Figure 8: Graph of individual data from behavior space experiment with regression line

The regression line shows an indirect relationship between having predatory trading and total wealth in the market with a somewhat low R-squared value. Therefore, these results seem to suggest that predatory trading has a small negative impact on the market's wealth as a whole.

Conclusion

This model, while capable of providing insights, is not a perfect simulation of the complex stock markets. Therefore, none of the results can be taken as definitive proof of predatory trading's harmful effects in the real world. However, the results should evoke some thought and provoke some consideration as to just how harmless predatory high frequency trading really is.

In conclusion, the model not only shows that predatory trading occurs at the expense of the ordinary investor, but it also shows that predatory trading is harmful to the total wealth of the market, albeit with a weak correlation. In addition, the model supports the claim that this practice of high frequency trading increases liquidity; however, it fails to

show any benefit in any other measures from that liquidity increase. This model doesn't attempt to simulate instability within the market, but it is likely that predatory high frequency trading wouldn't help the stability of the market either, despite increasing liquidity[6]. Overall, the results suggest that predatory trading skims off wealth from ordinary investors, many of whom have no idea that this is even happening to them. If the harm to these investors and traders isn't enough, though, predatory trading practices are found to decrease the total wealth in the market, a sure measure of harm as a whole.

[6] Drum, Kevin.

References

Drum, Kevin. "In Defense of "Flash Boys"" Mother Jones. April 7, 2014.
Lewis, Michael. *Flash Boys*. New York: W.W. Norton & Company, 2014.
Tumpel-Gugerell, Gertrude. "The Volatility of Financial Markets." Speech, Third Encuentro Financiero Internacional, Madrid, July 1, 2003.
"Volatility S&P 500". Yahoo! Finance, 2016.
Wilensky, U. (1999). NetLogo [computer software]. Evanston, IL: Center for Connected Learning and Computer-Based Modeling, Northwestern University. http://ccl.northwestern.edu/netlogo .
"Gallup Daily: US Economic Outlook." Gallup, http://www.gallup.com/poll/110824/gallup-daily-us-economic-outlook.aspx.