Grand-Exchange-Analysis-Notes

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1 Project Goal

The computer game Runescape has a central trading platform called the Grand Exchange. The Grand Exchange functions like a stock exchange and allows players to buy and sell commodities from each other. From the perspective of a trader wishing to profit by trading on the exchange, there are both benefits and drawbacks to trading on this exchange. The goal of this project is to analyze historical price data in an attempt to make accurate predictions and trade accurately and profitably on the Grand Exchange.

2 Introduction

The in-game currency is called "gold pieces" (gp). We have approximately 2 million gp with which to trade. Currently, there are two primary types of traders knowing as "flippers" and "investors."

Flippers are what we know as the frequent click-traders and market-makers. They submit buy and sell orders to fill up the price margin and profit off the difference. There is absolutely no analysis required for this: for liquid commodities, there is always a price margin and there will always be people willing to buy higher and sell lower. The drawback is that one must be constantly online and monitoring their trades because creating a trade bot is grounds for the game moderators to permanently ban your account.

Investors buy commodities when they are at low prices and sell when they are much higher. This may require some analysis as prices can sometimes be unpredictable: sometimes the price may be low, but it stays low for too long, sometimes the price may shoot up to new highs. Investing may be slower than flipping, but the benefit is that one does not have to be as active.

This project will focus on investor trading. Currently, we are aware the prices tend to cycle from highs to lows over multiple months, but we would also like to predict when these trends occur and find indicators. In addition, we'd like to forecast unusual trends, such as prices skyrocketing. Finally, since one cannot short-sell on the exchange, we would like find multiple commodities on which to trade so that we do not have to wait for the price of a commodity to drop after selling before we buy again.

3 Market Properties

This in-game market is somewhat different from real-world markets. In particular, there are several properties that make the market easier to deal with than a real-world market:

- There are no trade commissions
- There are few (if any) trade bots, and therefore latency is not a major issue.

There are also several properties that make the market more difficult to deal with than a real-world market:

- The order book is not visible
- Average prices are only published daily
- We cannot short-sell a commodity
- Bots for mass-producing commodities may significantly influence the supply/demand, but this factor is invisible to us. This is more common than a trade bot because there is no risk in gaining profits. The bot produces commodities, sells them, and transfers profits to other accounts. If the bot is banned, the player just makes another one.

4 Determining Commodities on which to Trade (Profitability Filter)

Whether a commodity will be good to trade on depends on properties of the commodity. In addition, we have to consider how much money we have to invest and how much time we have.

For this analysis, we will pretend we are allowed to short-sell. This assumption should be valid because we should not penalize items whose prices fall - otherwise, we would be selecting for items whose prices only rise, an impossible property.

Suppose we have G gp. Let's say we consider commodity x. There will be some properties of interest:

Average maximum price changes: This determines if we are able to make a profit at all by taking a long position and then clearing it when the price rises.

We may consider the 1-day, 7-day, 30-day, or 90-day or k-day (where k is any desired duration) average price change. This works by assuming we purchased the commodity on some day and finding the maximum price difference within the given time frame. We take the absolute value only, to account for potential profits from short-selling.

Trend Line Reversals: If a commodity's price trend never changes, we will never clear our position at an optimal time. Specifically, we wish to use this property to identify extremely bad commodities for trading, such as worthless items, whose price falls with an asymptote at 0 gp. We use the average price trend line because a continuously falling price may sometimes fluctuate and increase, but that fluctuation is just an anomaly.

Trade Volume: We need to be able to buy/sell appropriate quantities. If a given commodity is not liquid and we need to trade on high quantities of that commodity, then trading on that commodity will prove disastrous.

Using the above properties, we can now check if x is a good commodity on which to trade. Let the most recent price of the commodity be R. Let the average trade volume (over the past 90 days) of the commodity be v. Then the maximum quantity, q, of the commodity we can feasibly buy is given approximately by

$$q = \texttt{min(}\ v\ \texttt{,}\ \tfrac{G}{R}\ \texttt{)}$$

Suppose we are interested in clearing out our position within k days. Let the average k-day price change be c. Then the expected average profit, P, would be

$$P = cq$$

We can apply this calculation to all commodities with fluctuating prices and sort the list by descending expected profit. We say a commodity has a fluctuating price if the trend of the 180-day average price reverses at least 4 times in the last 180 days. If it doesn't have this property, we automatically define its profitability to be 0.

Finally, the items at the front of the sorted list would be the best commodities on which to trade.

5 Results and Accuracy of Profitability Filter

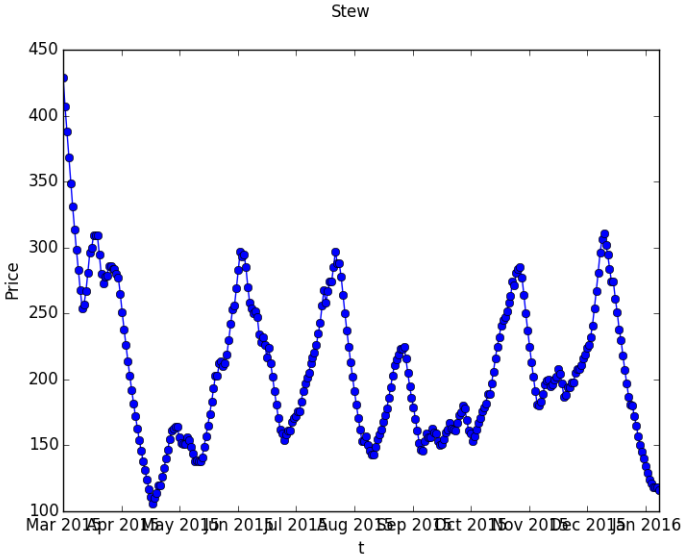
Here are the top 10 items on the list expressed as tuples `(name, commodity ID, expected profitability)`:

```
Rope,954,6859232.13873
Red topaz,1613,3166954.08889
Opal,1609,2709454.84459
Red partyhat,1038,2441650.97895
Silver bar,2355,2309141.78596
Snakeskin body,6322,2221562.25832
Antidote++(4),5952,2032936.45614
Stew,2003,1962812.23158
Jade,1611,1950190.78559
Water talisman,1444,1942029.34087
```

Some items belong in the top-10 list, while others do not. We now provide examples of each category.

5.1 Correct Categorization: Stew

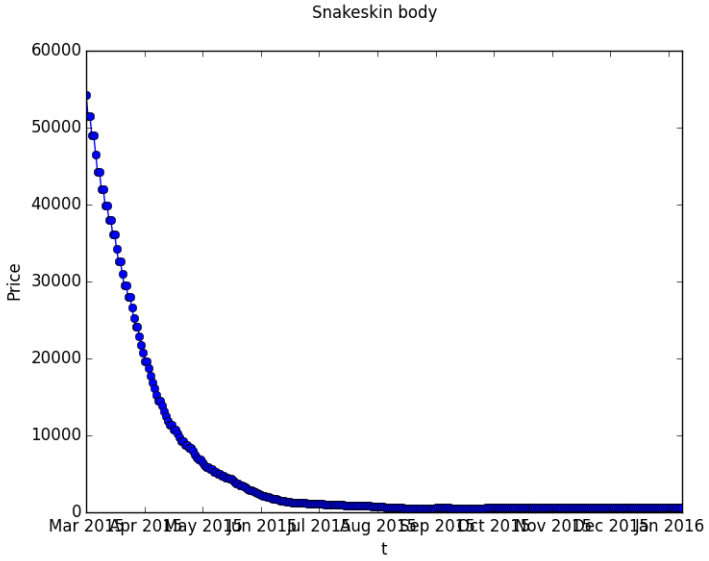
The algorithm successfully identified items that are good to trade on. For example, the following is the price graph of the commodity "Stew:"



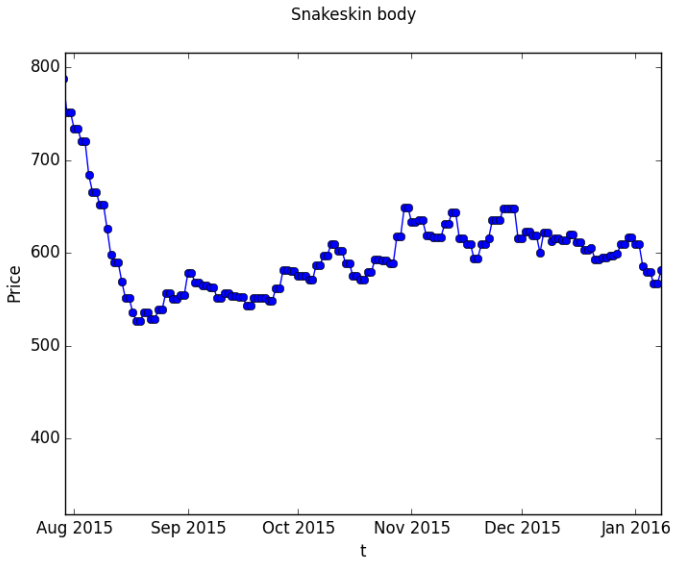
As we can see, this is an item with an average price of around 225 gp and its price difference tends to be around 150 gp. This means that successful investment could yield nearly 66% profits. Thus, we conclude the algorithm correctly identified "Stew" as a good item in which to invest.

5.2 Incorrect Categorization: Snakeskin body

As with a prior machine learning algorithm, we noticed that one of the drawbacks was the inability to differentiate price-fluctuating items whose prices fell heavily recently from items whose prices fell heavily but otherwise do not change that much. For example, consider the item "Snakeskin body" with the following price graph:



It appears that this commodity's price is just always falling and we might believe that it should not be profitable to invest in it. Further examination by zooming into the recent prices confirm our suspicions.

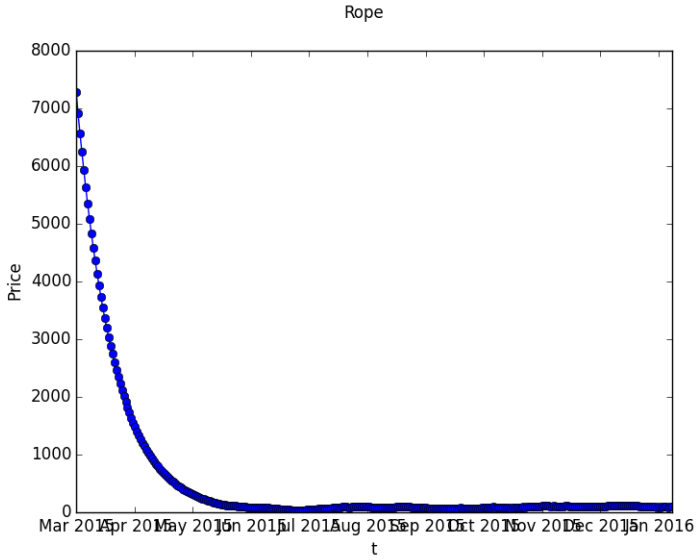


Prior to Sep 2015, the price of the "Snakeskin body" was continually falling from over 60000 gp. This price fall meant that had we taken a short position on "Snakeskin body," we would have had huge profits. This is not so relevant in recent times. As we can see, the the price of "Snakeskin body" now averages around 600 gp and the price change is only around 100 gp. This only yields 16.67% profits when traded optimally. If traded non-optimally, the profits would

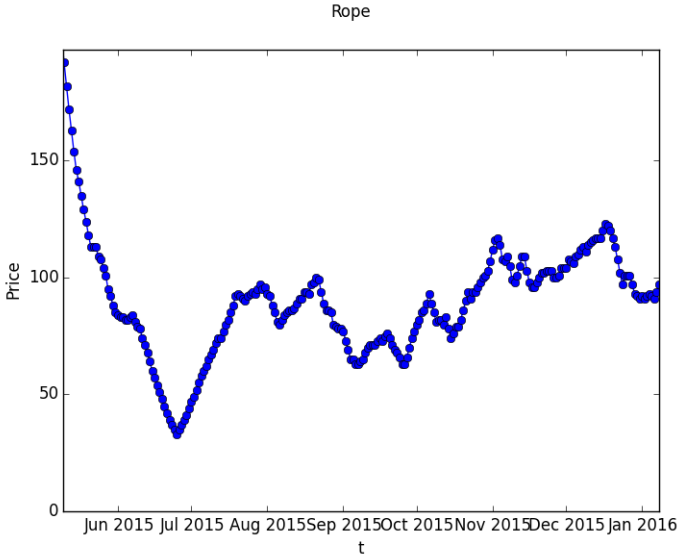
be even smaller. Thus, "Snakeskin body" was wrongly included in the list of items on which to trade. It was wrongly included because the system erroneously believed that "Snakeskin body" was a promising commodity due to the massive profits that would have been realized by taking a short position when it was worth over 60000 gp. This is one of the drawbacks to allowing the system to consider taking a short position.

5.3 Correct (tricky) Categorization: Rope

There is also some middle ground. Consider the commodity "Rope" which has its price graph shown below:



It has the same shape as the price graph for "Snakeskin body." However, when we zoom into the graph, the situation changes.



Prior to September 2015, the price of "Rope" was also continually falling from over 7000 gp. If we looked at the first graph that begins in Mar 2015, we would mistakenly believe that the price of "Rope" is continually falling. Once we zoom in, we see that the price of "Rope" is actually fluctuating nicely. It has an average price around 80 gp and a price difference averaging around 60 gp. Thus, investing in "Rope" could potentially yield around 75% profits, which is a good result.

If we had restricted ourselves from considering "Rope" because of the huge price fall at the beginning, then we would have incorrectly discarded a promising commodity. Thus, the process of categorizing promising and not-promising commodities is not so straightforward.

5.4 Next Steps

It may be promising to consider the commodities without allowing short-selling. In this scenario then, we would only look at price increases and ignore any price decreases over each time frame.

6 Determining Price Change Indicators