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 Profitability Filter: Determining Commodities on which to Trade

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.

Since we cannot short-sell, our analysis will ignore large price falls as well. Suppose we have G gp. Let's say we consider commodity x. There will be three features of interest:

Average maximum historical profit: 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 best time within the k-day window to sell and recording the profit per unit. The profit per unit is then averaged over all possible k-day windows in the past.

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

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

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 6 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

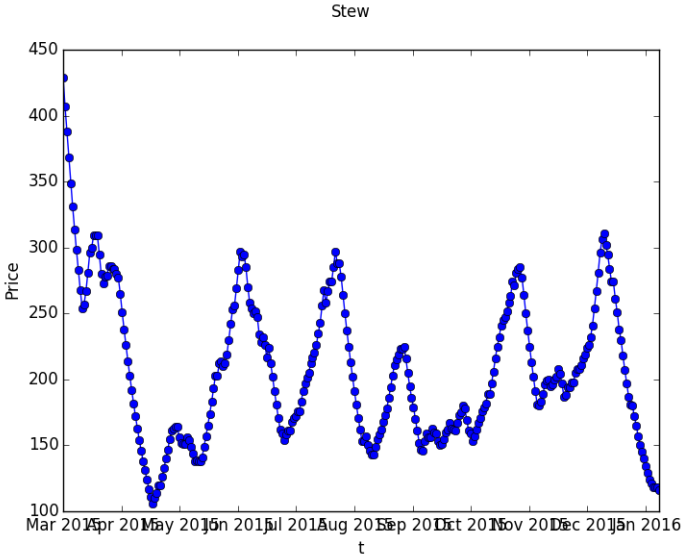
As an example, here are the top 10 items on the list expressed as tuples `(name, commodity ID, expected profitability)`:

```
Red partyhat,1038,1656735
Santa hat,1050,1264422
Stew,2003,1224111
Dragon axe,6739,668304
Kraken tentacle,12004,653944
Kwuarm seed,5299,653106
Dragon spear,1249,596222
White berries,239,570900
Cosmic rune,564,525000
Karil's coif,4732,486020
```

For the most part, the items in this list a reasonable and belong in the top-10. The filter, unfortunately, misses some promising items though. In the following sections, we provide some examples of correct and incorrect categorizations

5.1 Correct Categorization: Stew

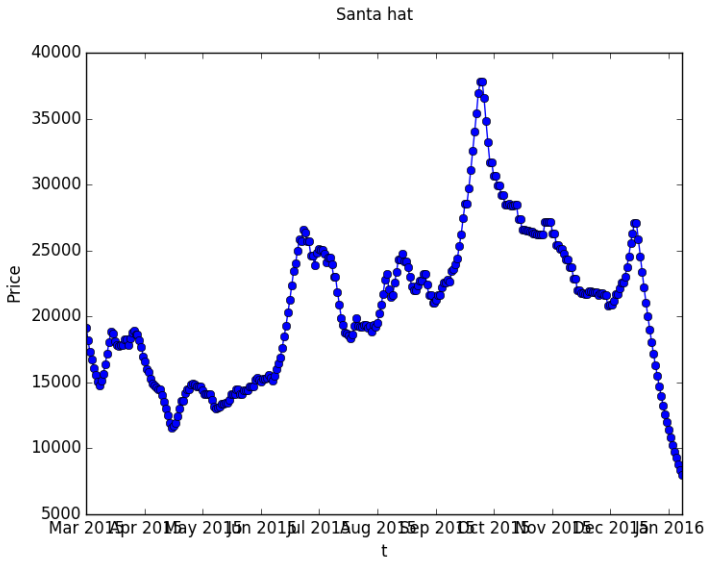
The algorithm successfully identified items that are good to trade on. For example, the following is the price graph of the commodity "Stew:"



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 (Potentially) Correct Categorization: Santa hat

The algorithm questionably identified "Santa hat" as an item that is good to trade on. Below is the price graph for "Santa hat."

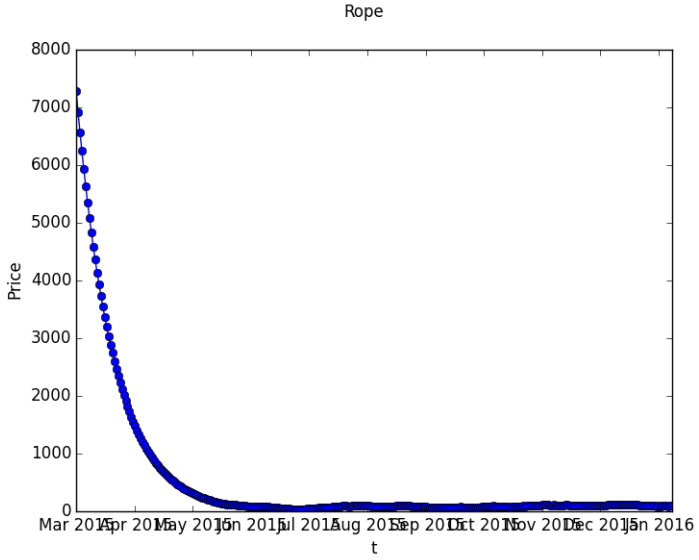


One issue with the filter is that it does not account for seasonal items, such as "Santa hat," which becomes extremely cheap around Christmastime because people receive holiday items for free during the holidays. So, given that the current date is slightly after Christmas, it is not a good time to trade on "Santa hat." As we see from the following price graph, its price is continually falling. On the other hand, during the summertime, the price of "Santa hat" fluctuates much more and is more profitable to trade on "Santa hat" then. In this example, the categorization of "Santa hat" could go either way.

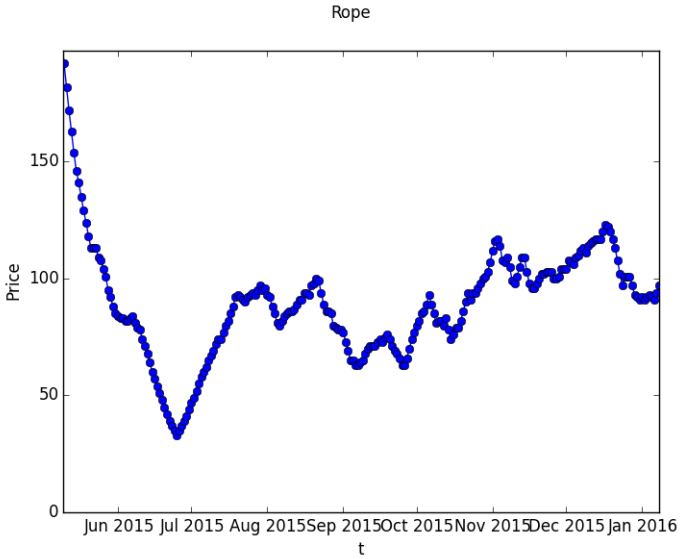
5.3 Incorrect Categorization: Rope

Unfortunately, the profitability filter also misses many items that would be good to trade on. However, it is much better to have more false negatives, fewer false positives, and a clean top-10 list than to have more fewer false negatives, more false positives, and a top-10 list riddled with errors.

Consider the commodity "Rope" which has its price graph shown below:



It looks like the price of "Rope" is continually falling, and we would expect the trendline of "Rope" to not reverse very much. Thus, the profitability filter filtered out "Rope" from the list. However, we can zoom into the graph for more recent times and the situation changes.



Prior to September 2015, the price of "Rope" was continually falling from over 7000 gp. This was a huge bias and maintained a falling trendline. Once we zoom in for recent price data, 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 actually better than the item "Stew," which made the top-10 list.

We expect that as time goes on and we obtain more datapoints, the biases from earlier prices will become less relevant and items like "Rope" will end up being categorized correctly.

5.4 Next Steps

Once we have determined items that are promising to trade on, we will look for indicators in other commodities that may foreshadow an unusual price change in a commodity.

6 Determining Price Change Indicators