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**Overview:**

For the FE 522 final project, our team chose a project where we calculated different liquidity measures for a particular. We decided to use Pfizer stock and the liquidity measures would be computed using effective spread, realized spread, and the roll model. We collected the trade and quote data for Pfizer TAQ filestock for the 10th of November 2020. We found differing results from each method and will discuss our procedure and analysis throughout the report.

**Data Source:**

We collected our data from Bloomberg for the Pfizer stocks on November 10, 2020. We chose Pfizer particularly because of the high liquidity and volatility the stock provided during the month of November 2020. The reason for this being the COVID-19 vaccine news and the election results. This provided us with good microstructure data for one day to work with.

*Figure 1* shows the raw data collected from Bloomberg. It shows the bid price, the ask price, trade price, bid volume, ask volume, trade volume, exchange at which it is traded and the times at which the transactions occurred.

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*Figure 1: Raw Bloomberg TAQ Data*

We modified the file to align with the C++ code used to compute the spread measures. The file was modified to have just the bid price, ask price and the trade price.

*Figure 2* shows the modified data. We used this data in a txt file as input to our C++ code.

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*Figure 2: Modified TAQ Data*

**Liquidity**

Liquidity the measure of depth of the market. It tells us how easily something can be bought or sold in the market. That is, how easy it is for an asset, or security, to be converted into ready cash without affecting its market price. It is a way of measuring the depth of the market.

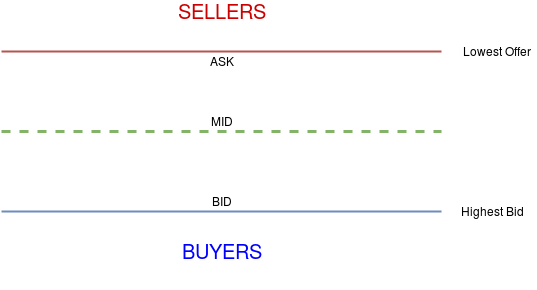
Liquidity of the markets allows for rapid and cheap trade execution. It is the most important characteristic of well-functioning markets.

**Bid-Ask Spread**

The bid-ask spread is the difference between the bid price for a security and its ask price.

That is, it represents the difference between the highest price a buyer is willing to pay for a security and the lowest price a seller is willing to accept.

*Figure 3* provides a visualization of the bid-ask spread. The mid-price is given by



*Figure 3: Bid-Ask Spread*

**Methods Used**

The three methods we used to calculate liquidity for Pfizer were Effective Spread, Realized Spread and Roll Model.

**Effective Spread**

This is a measure of actual trading costs. It is the signed difference of trade price and mid-price.



Where*Dt* is the trade direction and is +1 if trade us ‘buy’ and -1 if trade is ‘sell’.

To calculate Effective Spread in C++, the data file is taken as input. The file is opened using ifstream function. The first row which is the heading is stored in a vector of type string using the getline function. The remaining data is stored row by row in a vector of type DataRow. DataRow is a user defined class which has bid, ask and stock price as member variables.

To calculate the effective spread for each bid-ask pair, data is passed to EffectiveSpread class. This class is another user defined class. This class has a member function eSpread () to calculate Effective Spread based on the formula mentioned above.

The formula has a parameter . This is calculated by comparing stock prices. If stock price at time t is greater than stock price at time t – 1, then Else

The output is given to an output.txt file. The average of Effective spread is calculated by adding Effective Spread for each bid-ask pair and dividing it by the number of bid-ask pairs.

Data from input file is given to vector of type DataRow by operator >> function. And data in output file is passed by operator << function.

**Realized Spread**

Since effective spread does not take into account price movements induced by trading, realized spread adds a delay to the mid-price for five minutes allowing the price impact to be absorbed into prices. Realized spread is used to measure the cost of immediacy because after each trade, the dealer adjusts the quote in order to reflect the information in the trade.



Like Effective Spread, Realized Spread is calculated by defining a class named RealizedSpread. For each bid-ask pair, data from vector of type DataRow is passed to class RealizedSpread. This class has a member function rSpread () to calculated Realized Spread using the formula mentioned above. is calculated by comparing stock prices, like Effective Spread. Realized Spread considers time lag. Lag of 5 minutes is taken to consideration.

The output is given to an output.txt file. The average of Realized spread is calculated by adding Realized Spread for each bid-ask pair and dividing it by number of bid-ask pairs.

Data from input file is given to vector of type DataRow by operator >> function. And data is output file is passed by operator << function.

**Roll Model**

The Roll model provides a simple model of how the Bid- Ask spread might affect the time series properties of the returns.

The Roll model is based on the following assumptions, whereis the trade sign variable.

1. Balanced order flow: Buys and sell are equally likely and occur with probability
2. No autocorrelation in orders:
3. Trading and the efficient price process are uncorrelated: trading does not have any effect on the mid-quote.
4. Constant and zero expected return

In Roll model, Trade Prices are expressed as, where is the trade direction indicator:   if the trade is a buy and   if the trade is a sell.

Programmatically to calculate spread using Roll Model we have created RollModel class in which we have member functions like mean(), covariance(), and RollSpread(). Initially before pass data through these member functions the data is cleaned in the constructor to only have non zero values and then store it RollData vector. To calculate the direction of the trade at time t and t-1 we have calculated the difference in Stock Price and stored in deltaP and deltaP1 respectively. Later using the above mention formulas are used to calculate the spread using Roll Model.

**Results**

After using these methods on our dataset, we were able to calculate the effective bid-ask spread along with the realized spread for the 5 min time-lag and the roll model calculation of bid-ask spread.

A table of these values can be seen below:

|  | **Effective** | **Realized (5 min)** | **Roll model** |
| --- | --- | --- | --- |
| **Spread ($)** | 0.158127 | 0.013172 | 0.00589671 |

There are large differences between these values. The effective spread is approximately 1.5$ This indicates that at the time of each trade the expected value of the actual trading costs was approximately 1.5 dollars. However, the realized spread at 5 minutes, with a value of 1.3 cents, is much lower than the effective spread. This shows that the price impact in this data was large.

The roll model estimate of the spread is the smallest spread value of all. The roll model attempts to estimate the effective spread of the data. From this standpoint, the roll model was very inaccurate as it estimated the effective spread to be way less than true value of the effective spread.

This difference is easily explainable as the roll model is known to have its limitations. The assumptions that the model makes, such as that buys and sells are equally likely, appear to have caused it to be very inaccurate.

**Why is Liquidity Measure Important?**

The stock market is characterized by higher market liquidity. If an exchange has a high volume of trade that is not dominated by selling, the price a buyer offers per share (the bid price) and the price the seller is willing to accept (the ask price) will be fairly close to each other. Investors, then, will not have to give up unrealized gains for a quick sale.

The most liquid or widely traded securities tend to have the narrowest spreads, as long as there are no major supply and demand imbalances. If there is a significant imbalance and lower liquidity, the bid-ask spread will expand substantially. Some shares trade more actively than others on stock exchanges, meaning there is more of a market for them. In other words, they attract greater, more consistent interest from traders and investors. Like for example, popular securities will have a lower spread (like Apple, Netflix, or Google stock), while a stock that is not readily traded may have a wider spread.

This is why liquidity measure using bid-ask spread is an important consideration for most investors because it is a hidden cost associated with trading any security.

**Summary**

Our group performed our analysis and concluded that at different time steps the measurement of liquidity changes. We learnt that by using high frequency trading data at microsecond levels, we could extract a more detailed and thorough analysis of the liquidity measures of the stock, as opposed to live market data that does not capture details at such a high level.

For future research, using a more robust model such as the Glosten-Harris model (an expansion of the roll model) could provide a more useful estimate.

**Sources**

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