Chapter 3 - A Supply and Demand Model for Stocks

written for Economics 104 Financial Economics by Prof. Gary Evans
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There are few markets in the world that are more active or competitive than the market for stocks. Stock prices in every exchange in the world fluctuate actively at every moment throughout the trading day for any market that is open, and the prices of many popular stocks continue to move on a long cycle in the increasingly active electronic after-hours markets. Companies of larger and more popular stocks like Intel **(INTC)** generally trade with enormous volume, which implies that the price of Intel stock can, and does, change at any moment.

But what causes the price to change? Why does the share price of Intel rise and fall in value?

This chapter introduces an elementary **Supply and Demand Model** for stocks. The intent here is to give us an analytic perspective on why stocks rise and fall in value. This chapter does not so much discuss the multiple variables, like earnings and dividends, that affect stock prices. Those variables are mostly discussed in **Chapter 4**, although by necessity some variables are discussed in this chapter. Mostly, though, the intent here is to set up a model that explains the mechanics of the interaction between **Supply** and **Demand**.

Here is what I intend to cover:

1. The logical justification of **Supply** and **Demand** curves and what they represent.
2. Multiple examples of shocks to **Supply** and **Demand** curves and an explanation of why the cause stock or index prices to rise or fall.
3. Using the model to understand or explain general market conditions rather than the behavior of individual stocks.
4. An introduction to four-quadrant analysis

1. Setting Up the Model

To begin construction of the model, we have to remember that when you buy 100 shares (or so) of a stock like **AAPL**, it is similar to buying a used car. You are certainly not buying the stock from the Apple Incorporated (their actual legal name). That company benefitted from the sale of this stock on the day of the IPO, decades ago, when the stock was sold to the public for the first time. That is how Apple was initially capitalized, at least in part. Since then, although shareholders, employees, executives, and other investors have all benefitted from the resale of Apple stock, the abstract corporation itself has received no additional benefit beyond the IPO, no matter where the share price has gone[1].

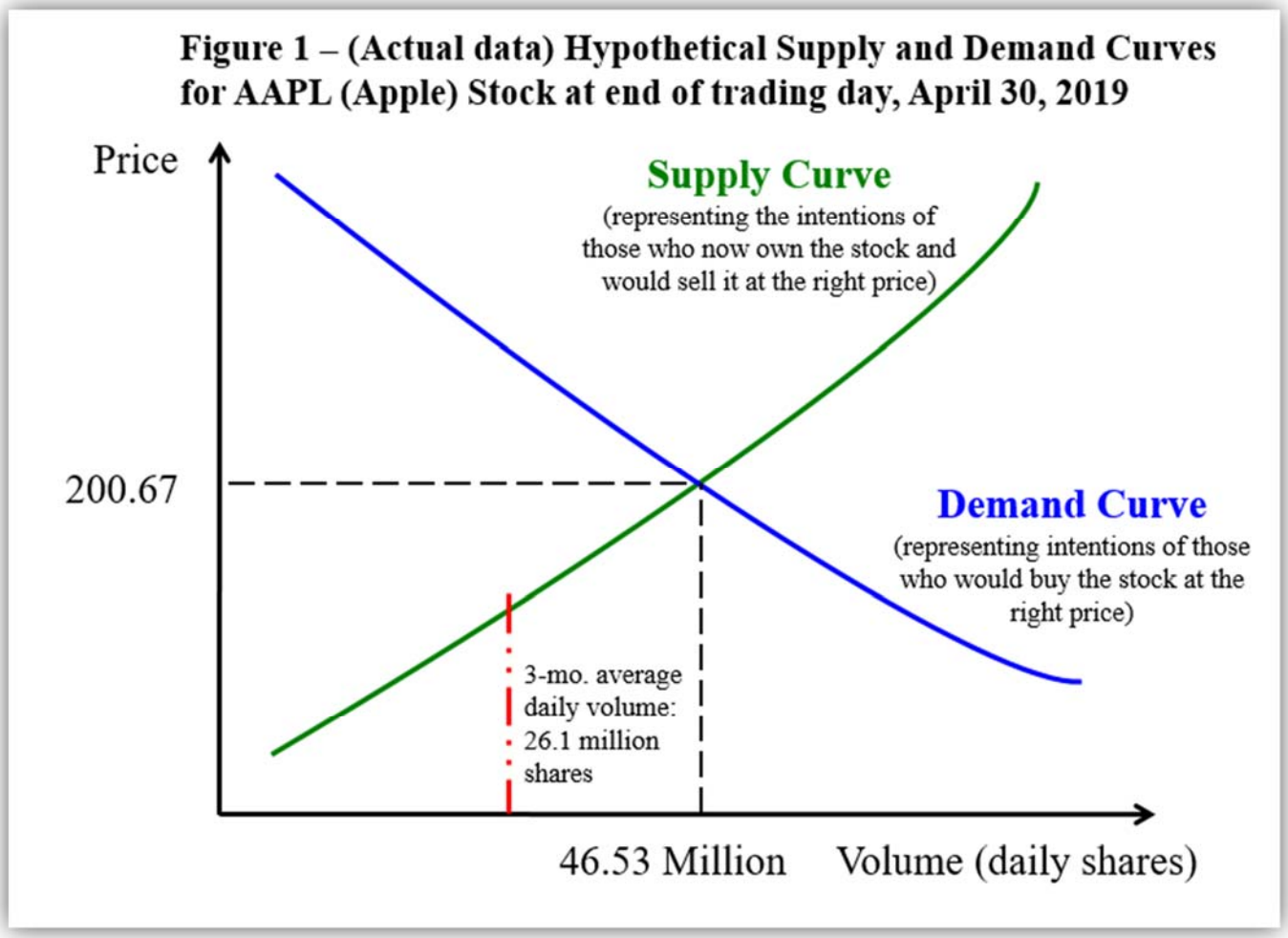
If you buy stock, you will be buying it from someone who earlier bought it like you are trying to do now, and when you sell it you may be selling it to someone who may be buying it for the first time.

It will also be useful to remember that once you buy stock, you can usually turn around and sell it back to the market at any time you want. You can hold the stock for 10 years, or you can sell it two minutes after you bought it, or if you have programmed a trading computer to buy and sell, that computer can literally execute a trade to sell a few milliseconds after it executed a trade to buy.

Ultimately the price of any stock (and generally any financial asset traded by markets) will be determined by the ebb and flow of supply and demand for the stock in question. We can represent this market with an ordinary supply and demand model for shares of the stock, as though representing the supply and demand for gasoline, so long as we make a few qualifications.

[1] We remember from chapter 1 that some capitalization comes before the IPO, and companies can and frequently do have secondary public offerings and later public offerings for more shares of stock in the months or years following the IPO. This has the same effect of an IPO, adding more cash capital to the company itself.

Refer to **Figure 1**, which represents the supply and demand curves for **AAPL** stock. To make the example, which is mostly hypothetical, a little more realistic, I have chosen an actual closing price ($200.67 per share) and daily volume (46.53 million shares) for April 30, 2019. Trading volume on that day was considerably more than the annual daily average at that time, which was 26.1 million shares (shown with a red dotted line as a point of reference).



The blue **Demand Curve** shown in **Figure 1** is meant to represent the intentions of thousands, possibly millions, of investors who are considering buying **AAPL** at various prices. The **Demand Curve** has a negative slope because it is *cumulative*. Anyone willing to buy **AAPL** at $210 per share would certainly also be willing to buy **AAPL** at a lower price, like $190 per share. We know from the discussion of limit orders that a potential buyer interested in buying **AAPL** at no more than $200 will typically enter an order to buy, called a bid, at the price of $200 *or lower*. That will be the typical bid. Therefore, the lower the price, the larger the number of trades that would be made at that price.

Given what was said above in the opening paragraphs, the green **Supply Curve** shown in **Figure 1** is meant to represent the intentions of thousands of investors who *already own* **AAPL** (because they bought it earlier, whether minutes ago or years ago) and will sell it at the right price. The **Supply Curve** obviously does not reflect any kind of offer generated by Apple. Like the **Demand Curve**, the **Supply Curve** is cumulative and therefore has an upward slope. The higher the market price at any moment, the more shares will be offered for sale.

The supply and demand curves fluctuate all day long in response to news, earnings reports, or anything else that might affect investor sentiment (discussed in the **Chapter 4**) and the price moment by moment will reflect these fluctuations in supply and demand. In our example, the market pauses at the end of the normal trading day with **AAPL** priced at $200.67 per share and volume for the day as shown. Obviously volume is fluid and must be expressed as a flow over some period of time, such as daily or hourly.

Example 1 (Figure 2): Good Earnings Causes the Stock Price to Rise

Individual stocks are of course very responsive to news. The new can be new information about the company itself, the industry in which the company competes, and even general economic news to the extent that it can affect a major segment of a market or markets overall.

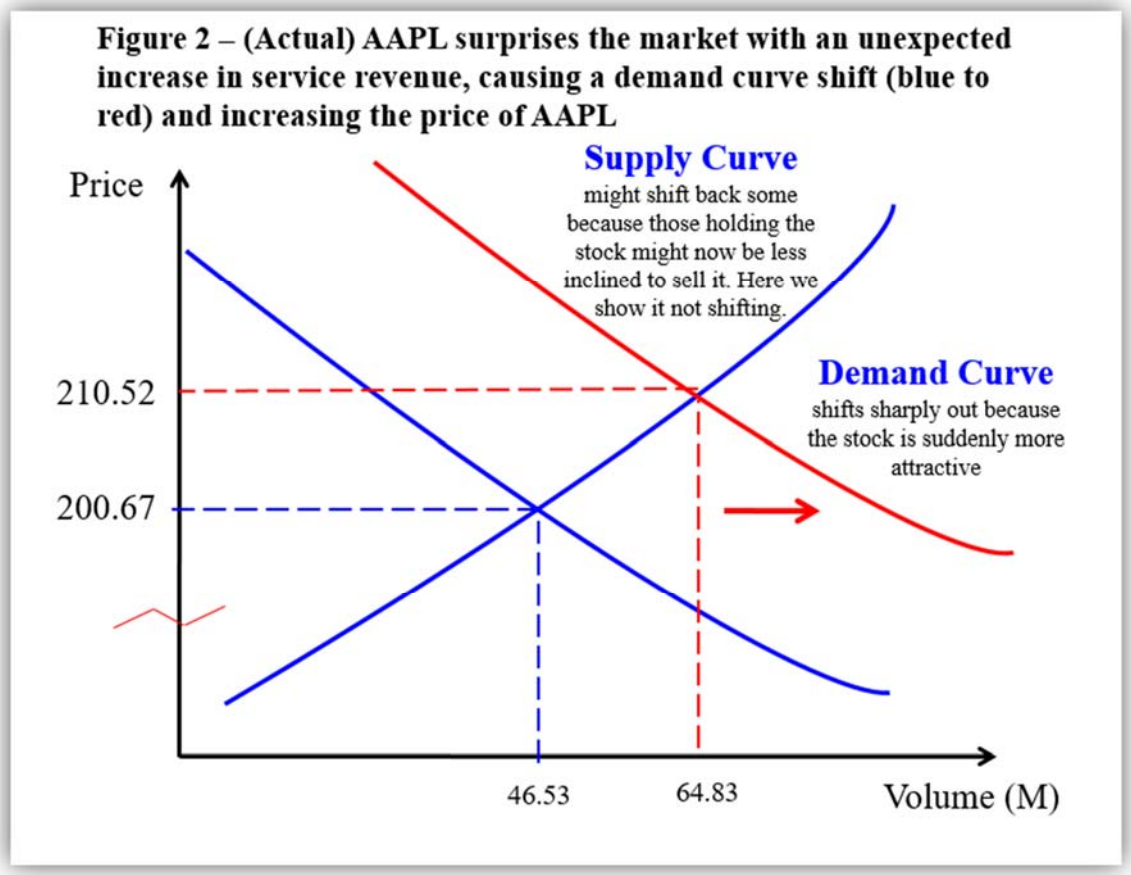


Figure 2 shows an example of how **AAPL** reacted to good news directly about the company, in this case an unexpected increase in earnings (profits). Tuesday, April 30, 2019 was chosen for this example because that day after the market had closed **AAPL** issued an earnings report. In a later chapter we will see that stocks in general react very strongly to rising earnings or higher revenue or greater prospects for either. The reason should be obvious - companies that are operating so well that their profits grow quarter after quarter will be rewarded with greater investor enthusiasm.

Publicly-listed companies report their earnings quarterly and usually analysts have generated some expectations about what earnings will be declared in the next quarterly report, typically stated as earnings per share. On April 30 after market close, **AAPL** posted earnings of $2.46 per share, which was actually down for the quarter. But they also reported a surge in service revenue, which analysts regarded as a positive sign. In reaction, on May 1, volume soared to nearly 65 million shares!

The **Demand Curve** shifted out because the stock is suddenly more attractive to potential buyers because of the company's greater profitability. In this graph the **Supply Curve** is shown as stable, but in this scenario the **Supply Curve** might shift back some, not shown, because some of those who currently hold the stock find it more attractive and might now be less inclined to sell it.

The net effect upon price of these two shifts is obvious - the price of **AAPL** rose, as is shown here rising from $200.67 per share to $210.52.

Generally, *any* kind of positive news about a stock has the potential to cause a reaction similar to the kind shown in this example.

In this example only a shift in the Demand Curve is shown, because in this example mostly demand would be affected. But in many scenarios both curves would shift.

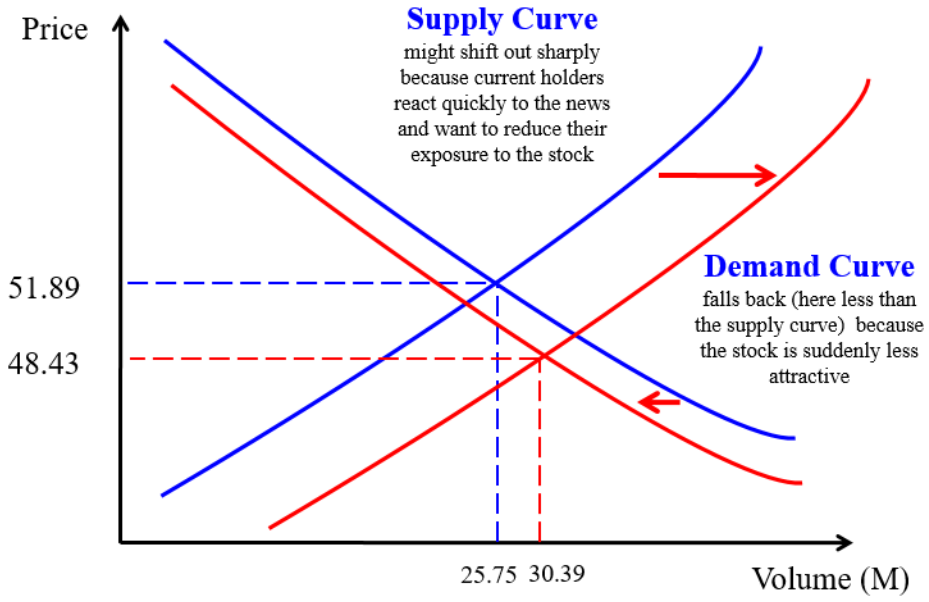
Example 2 (Figure 3): Negative News Causes the Stock Price to Fall

The rest of these examples are hypothetical and show what might have happened in reaction to other news.

It should be obvious that negative news, even if indirect (primarily about some other company) has the potential to trigger off a supply and demand reaction that can cause the price of a stock to fall.

Figure 3 shows a hypothetical example of the potential impact of a news release by a *customer* of **INTC**, which sells computer processors and chips to computer manufacturers like Dell Technologies In this example, the major computer manufacturer announces an unexpected drop in revenues (sales) in their quarterly report, and attributes the drop to declining computer sales in general. As might be expected the stock price of the announcing company falls, but so potentially does the stock price of any other company, including components suppliers, that might be affected by declining computer sales. This reaction is sometimes called a ***sympathy move***.

Figure 3 – (Hypothetical) A major computer manufacturer announces a sharp and unexpected drop in revenues, so in a sympathy move, chip manufacturers including INTC see their stocks hit hard.



In the hypothetical example of the impact upon **INTC** shown in **Figure 3**, the **Supply Curve** shifts sharply outward - this announcement caught the individuals, mutual funds, and hedge fund owners of ***INTC*** by surprise, and many of them rush to unload their holdings. **Demand** also falls back because stocks from this industry in general are suddenly less attractive. The net effect is a clear decline in price, shown in the example as a move from **$51.89** per share to **$48.43** per share.

Logically, the net impact upon volume would be ambiguous because it depends upon the relative shifts of the Supply and Demand Curves. In this example volume rises. As was the case when we looked at the impact of good news, there tends to be a dominant curve shift, and when the news is bad it does tend to be on the ***Supply*** side, so volume will usually rise in a case like this.

From this example it should be obvious that any good news in the sector (technology) and the industry (chip manufactures) is going to spread to many of the individual firms that make up the sector or industry. Many of the large cap stocks even respond to positive general economic news.

Example 3 (Figure 4) - Individual Stocks React to General Market News

This general response to economic news is represented below in **Figure 4** (again hypothetical), except in this case we are showing the reaction to negative news.

In **chapter 4** we will see that the major indexes will obviously respond to economic news. It makes sense then that any stock that is a component of an index can respond to the same class of news, even though the company is not directly affected by the news.

Figure 4 – (Hypothetical data) Stock markets are sluggish because of poor economic news (like emerging trade wars) and GM drifts lower to close at very low volume.

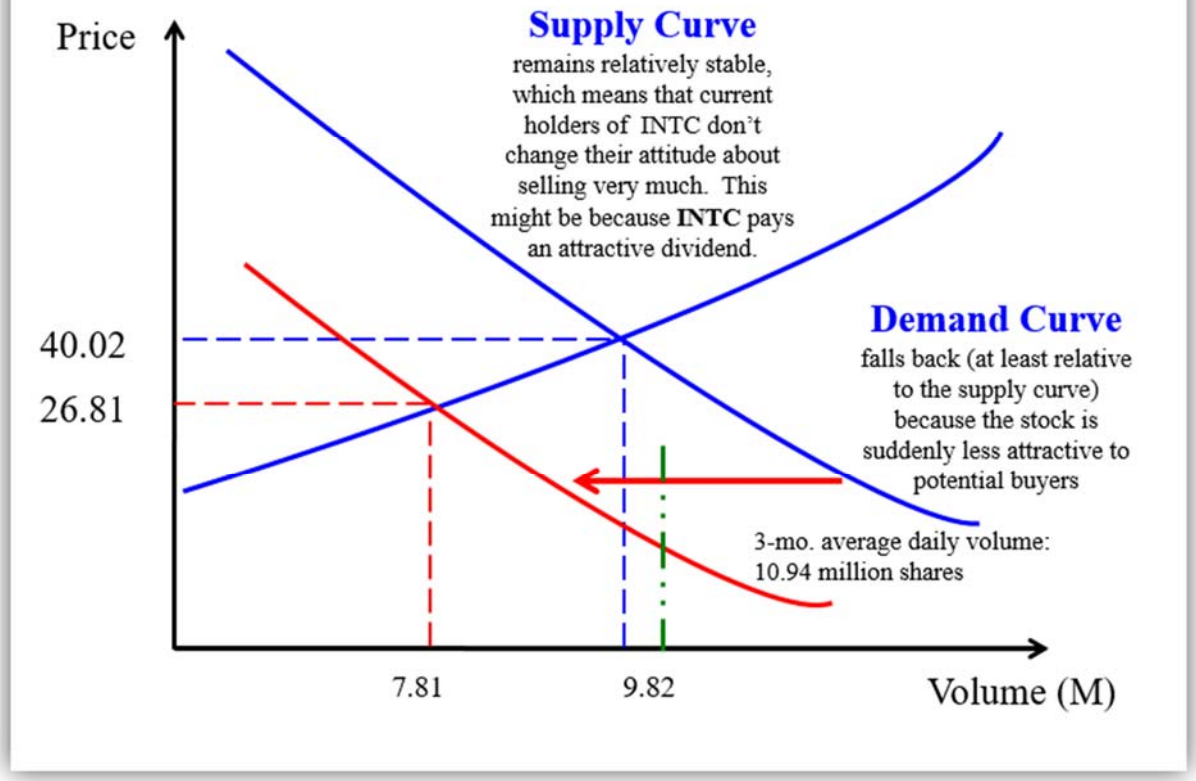


Figure 4 shows and example of how **GM** (General Motors) might react on a day when bad news has the effect of pushing down the ***S&P 500*** by one or two percent.

Candidates for such bad news in 2019 included the prospect for a tariff-based trade war between the United States and our trading partners. In summer 2018 President Donald Trump began imposing import tariffs against European and Chinese imports and China had threatened to retaliate by imposing import tariffs against autos made in the United States. The trade dispute was not resolved in 2018 and it continued well into 2019.

Clearly such an act might eventually have a significant impact upon **GM** because China was their fastest growing market. But such news could have a ***contagion effect*** and spread to other companies less directly impacted by retaliatory tariffs.

The contagion effect will happen if the news is perceived to be of such magnitude that the economy as a whole might be impacted, then the indexes decline and the move carries nearly all stocks down. **Figure 4** could have easily been representing an index instead of a stock. Of course not all stocks decline the same proportion during such an event. If import tariffs and a trade war is the perceived problem, probably **GM, F,** and **TSLA,** all of whom have major market share in China, will decline in much greater percentage terms than oil company Exxon Mobile Corporation (**XOM**), which does not.[2]

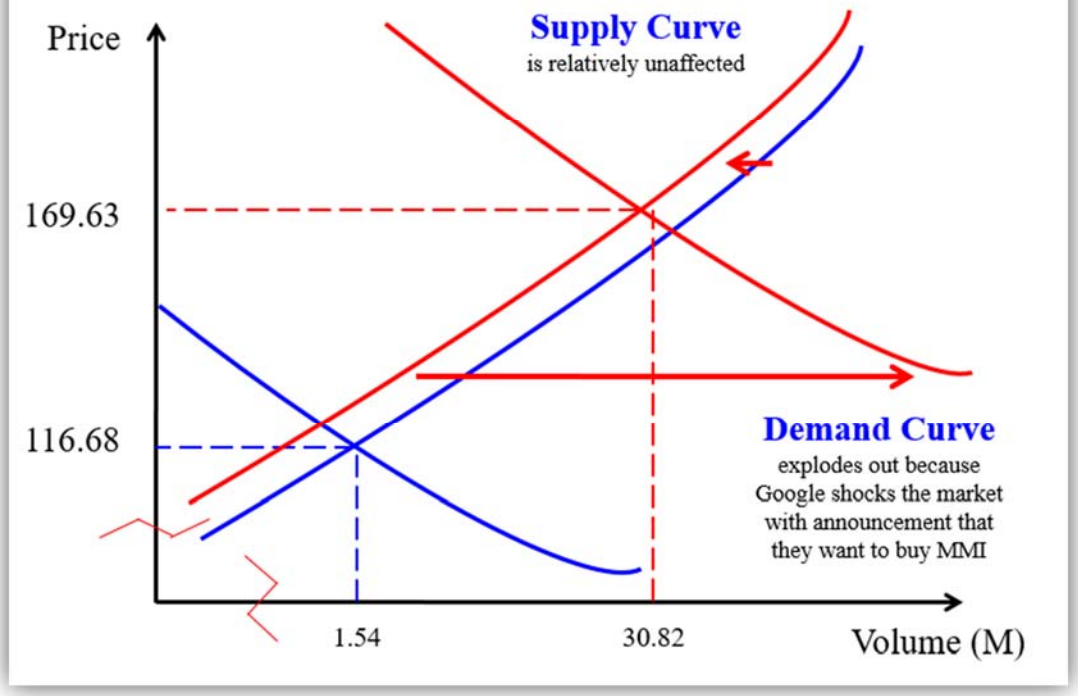
[2] This section might test the power of this chapter to be predictive! At the time this was written China had not retaliated by imposing higher auto tariffs and markets were hopeful that a more suitable arrangement could be negotiated. But if, by the time this section is read by the curious student, Chinese tariffs have been imposed, it might be worth a pause to see if the values of GM, F, and TSLA

Example 4 - Red Hat (RHT) Reacts to a Surprise Buyout Announcement from IBM

The next example is an actual event that happened late in the fall of 2018 and shows what can happen to the price of a stock when it becomes the welcome target of a friendly buyout attempt.

The buyout target in this case was Red Hat Incorporated (**RHT**), the Linux operating system service company, which was targeted in a friendly (non-contested) very generous buyout offer from International Business Machines (**IBM**). **IBM** offered RHT investors an astonishing **$190** per share when the stock was trading below **120!** This acquisition had a value of $34 billion and was the largest buyout attempt ever for **IBM**.

Figure 5 – The Market for Red Hat after IBM shocks the markets with the surprise October 29, 2018 announcement that they are buying Red Hat (RHT) for $190 per share.



On the last market day before the offer, Friday, October 26, 2018, **RHT** closed for the day at **116.68** and traded 1.54 million shares for the day. This initial equilibrium is shown in **Figure 5.**

When the announcement was made prior to market open on Monday, October 29th the market reaction was explosive, and is shown in **Figure 5**. **Supply** was relatively unaffected because it was understood that the **IBM** offer to buy the stock for **190** would stand for a long time. but **Demand** of course shot out, pulling the market open price up to **174.16** (not shown) near the offer price of **190**. The stock settled back down to close for the day at **169.63**. Volume from Friday's 1.54 million shares to Monday's closing 30.82 million shares.

Why didn't the stock go all of the way to **190**, since **IBM** announced in a press release that they intended to pay that amount? An acquisition of this scope is complicated, expensive, and time-consuming and must overcome regulatory hurdles - in particular anti-trust opposition. Therefore, the outcome is not guaranteed and there is some risk at this price, so the market price will often hover below the offer price until it is clear that the deal will be consummated.

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stock fell after the announcement, and whether markets as a whole, represented by indexes like the S&P 500 also fell. This section predicts the former in the event of new tariffs and suggests a high probability for the latter.

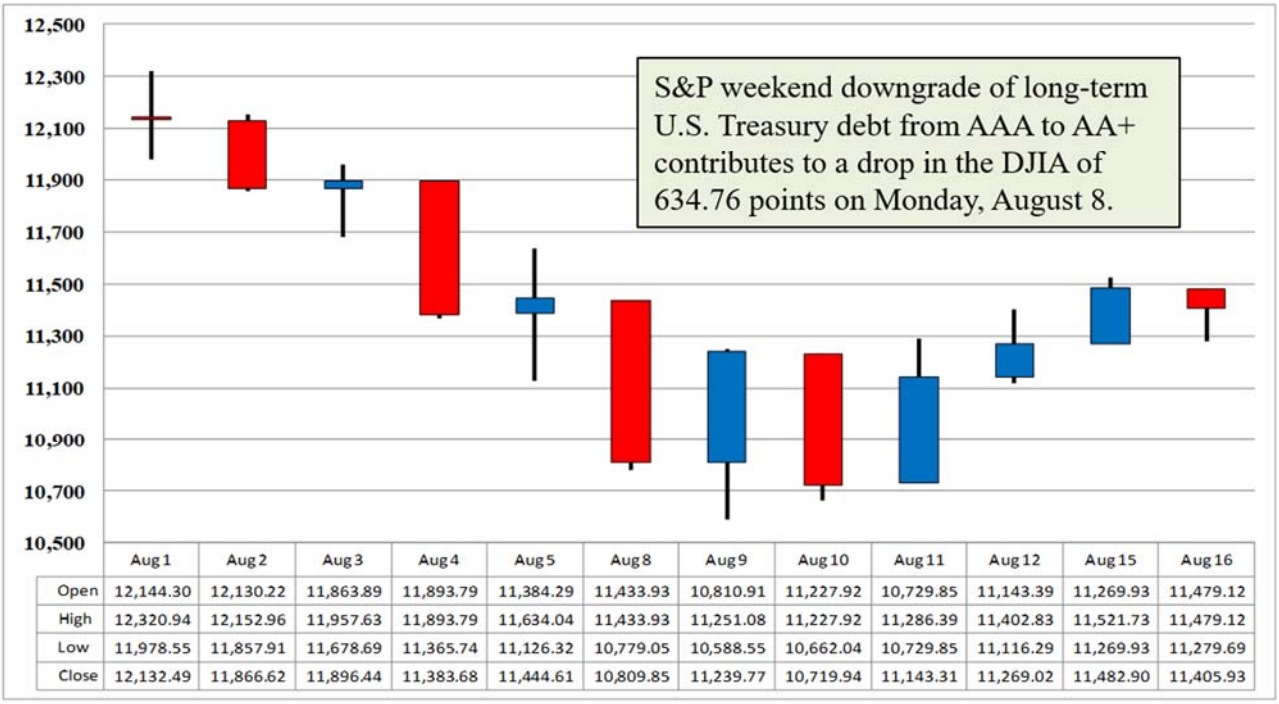
It finally was completed eight months later, the **$190** per share was paid to **RHT** shareholders, and Red Hat was delisted on July 8, 2019.

As a note of interest, the acquiring company often sees a decline, at least for a while, in the value of its stock when making an acquisition this large and controversial. After all, **IBM** was offering to pay 63% more for the stock than the market was valuing it at the time of the announcement, and **$34 billion** cash is a lot of money. Not all **IBM** investors would think that this is a wise market strategy. But in this case **IBM** neither rose nor fell, but stayed steady in the trading days that followed.

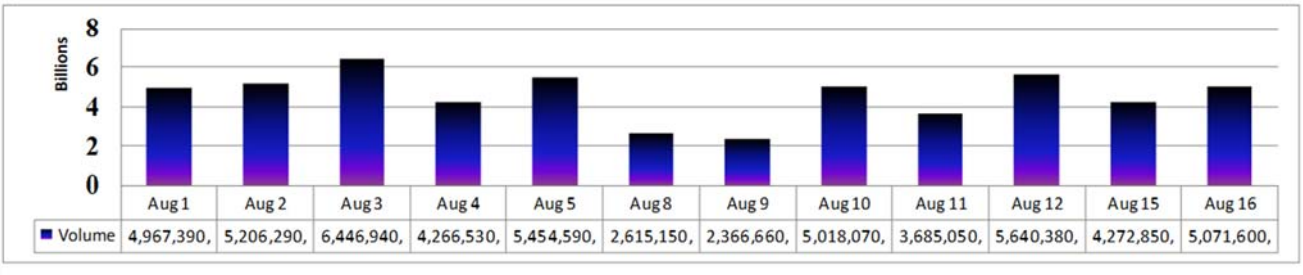
2. Using the Model to Evaluate General Market Conditions Instead of Individual Stocks

As suggested in the **GM** example above, the model that we have been using is easily converted to a useful model for evaluating entire markets, as represented by indexes like the **S&P 500** or Dow Jones Industrial Average (**DJIA**). After all, these indexes are weighted composites of the individual stocks that make them up and the **Supply Curves** and **Demand Curves** will aggregate into composite **Supply** and **Demand Curves** that behave much like they do in the disaggregated model.

Figure 6 – Open, High, Low, and Close Candlesticks and Volume for the Dow Jones Industrial Average, August 1 to August 16, 2011



	Aug 1	Aug 2	Aug 3	Aug 4	Aug 5	Aug 8	Aug 9	Aug 10	Aug 11	Aug 12	Aug 15	Aug 16
Open	12,144.30	12,130.22	11,863.89	11,893.79	11,384.29	11,433.93	10,810.91	11,227.92	10,729.85	11,143.39	11,269.93	11,479.12
High	12,320.94	12,152.96	11,957.63	11,893.79	11,634.04	11,433.93	11,251.08	11,227.92	11,286.39	11,402.83	11,521.73	11,479.12
Low	11,978.55	11,857.91	11,678.69	11,365.74	11,126.32	10,779.05	10,588.55	10,662.04	10,729.85	11,116.29	11,269.93	11,279.69
Close	12,132.49	11,866.62	11,896.44	11,383.68	11,444.61	10,809.85	11,239.77	10,719.94	11,143.31	11,269.02	11,482.90	11,405.93



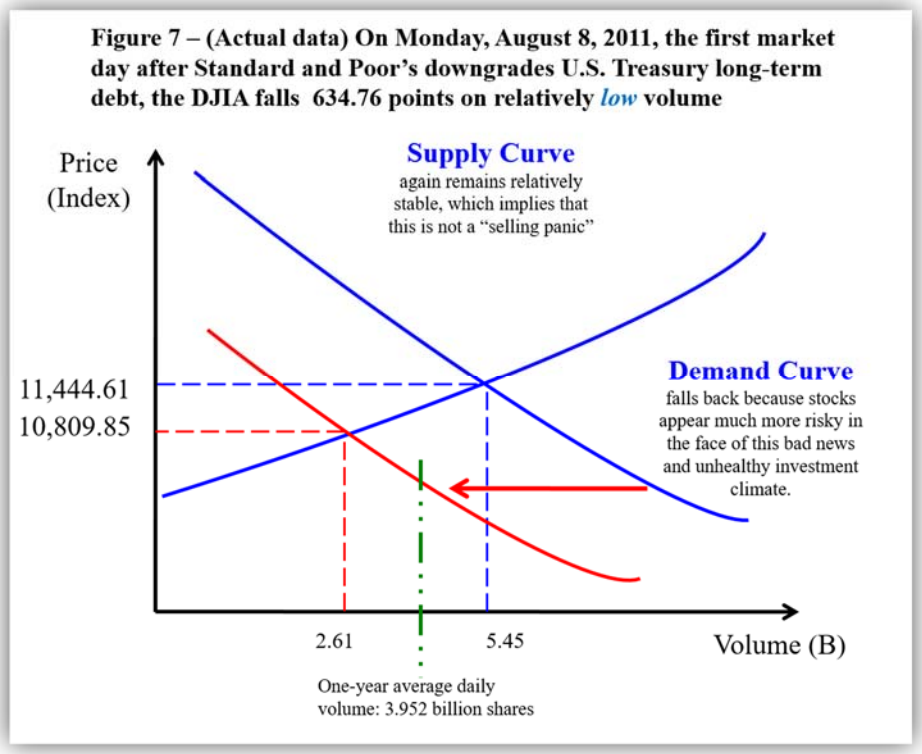
	Aug 1	Aug 2	Aug 3	Aug 4	Aug 5	Aug 8	Aug 9	Aug 10	Aug 11	Aug 12	Aug 15	Aug 16
Volume	4,967,390,	5,206,290,	6,446,940,	4,266,530,	5,454,590,	2,615,150,	2,366,660,	5,018,070,	3,685,050,	5,640,380,	4,272,850,	5,071,600,

Example 5 – The Dow Jones Industrial Average Reacts to a U.S. Treasury Debt Downgrade

It is best to demonstrate this by a real example, which was chosen because the market at the time was making some very severe moves. Look at **Figure 6**, which shows a candlestick chart of the open, high, low, and close of the **DJIA** for market days August 1 to August 15, 2011, along with another chart showing the daily volume of the 30 stocks that make up the **DJIA** for the same period.

Note that the price spread (highest to lowest) over this two-week period was over 1,800 points, about 15% of the index value.

Again we are looking at a candlestick chart. To remember what they represent, look at the candlestick for August 12 as an example. Because it is blue, that indicates that the market closed higher than it opened for the day (and red indicates a down day). The top of the wick represents the high of the day (**11,402.83**), the bottom of the wick represents the low (**11,116.29**), because this candlestick is blue the bottom of the candle represents the open (**11,143.39**) and the top of the candlestick represents the close (**11,269.02**).



This data period was chosen because it was unusual and very volatile and is a good example of the influence of political events upon stock prices.

In early August the Eurozone countries were beginning to have serious problems financing and refinancing the government debt of some member countries. In the United States the federal government had hit its debt ceiling and the partisan acrimony of recent years threatened to shut down the federal government. The U.S. Treasury Secretary at the time, William Geithner warned the markets that unless the debt ceiling was raised by August 2, then the U.S. could no longer borrow net new funds nor possibly roll over its short term debt, which would render the U.S. Treasury insolvent and possibly cause the first ever default on U.S. debt.

Meanwhile, in the background ratings firm ***Standard and Poor's*** was threatening to downgrade long-term U.S. Treasury debt from where it had always been since ratings began, AAA, to a lower AA+ rating. Generally ***Standard and Poor's*** saw no meaningful effort to reduce the scale of the budget deficit to historically tolerable standards.

Markets became very concerned about these developments, and as can be seen in Figure 6, stocks fell through the week from August 1 to August 5. Far more important, Standard and Poor's was unimpressed with the compromise, and late on Friday, August 5, they downgraded U.S. Treasury long-term debt from AAA to AA+.[3]

The first trading day after that downgrade was Monday, August 8, 2011, the day that we are reviewing here by example.

[3] The summary provided above doesn't do justice to the complex reasons provided by Standard and Poor's for downgrading long-term U.S. Treasury debt. To read their own explanation in their own words, see ***Standard and Poor's Research Update,*** *United States of America Long-Term Rating Lowered to 'AA+' On Political Risks and Rising Debt Burden,; Outlook Negative,* August 5, 2011.

First look at the candlestick in **Figure 6** for Monday, August 8, 2011, then look at **Figure 7**, which is meant to represent what happened during that day given the news context described above.

The red candlestick shows that it was a very bad day for the **DJIA**, recording a drop of **634.76**, about 5.5% It wasn't a record by any means, but any movement in the **DJIA** of more than 300 points is going to be a notable day.

Note also that there is no upper wick on the candlestick, which implies that the **DJIA** opened at its high for the day and fell relentlessly thereafter, closing very close to the low for the day, as made evident by the tiny wick on the bottom of the candlestick.

The is one more interesting phenomenon to observe - daily volume for the day was quite low, at 2.615 billion shares, about half of what it had been the previous Friday and well below the daily average for the previous year, 3.952 billion shares.

As **Figure 7** indicates, this price/volume combination implied by the **Supply** and **Demand** graph is informative. It clearly indicates that the large August 8 sell-off was *not* due to a seller's panic, which would have been indicated by a large increase in volume in addition to the sharp drop-off in price.

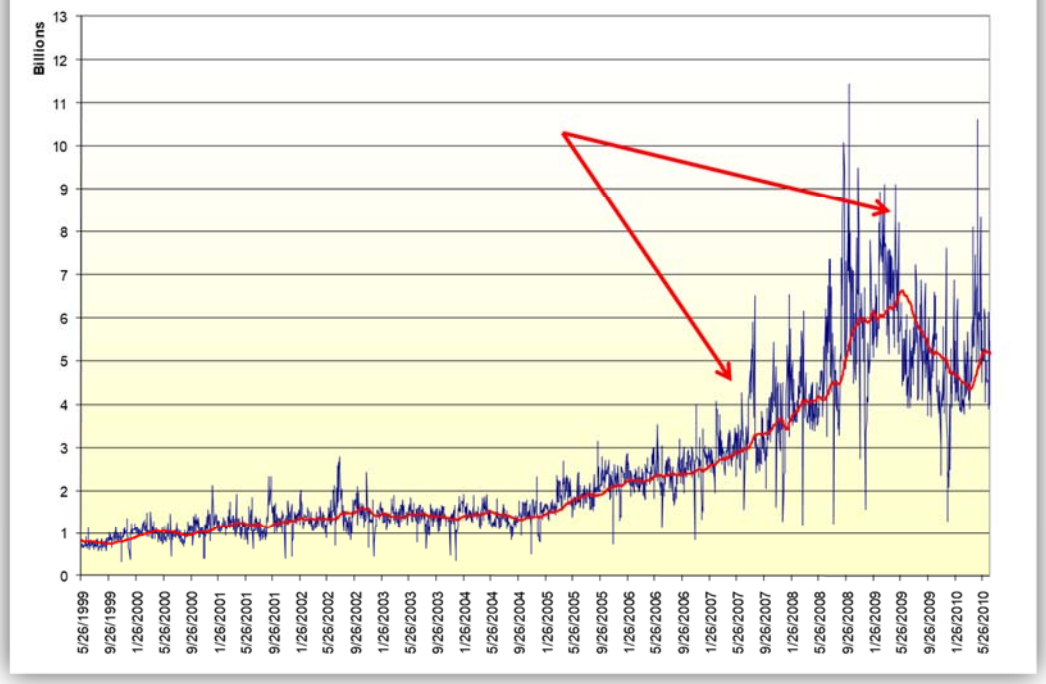
Figure 8 – The S&P 500, showing the sharp market drop between October 9, 2007 and March 9, 2009.

Example 6 – A High-Volume Market Sell-off

In contrast to the 2011 example, the terrible market decline that began in early October, 2007 and lasted until March 2009, which saw the **S&P500** lose well more than 50% of its value, was accompanied by a very substantial rise in volume,

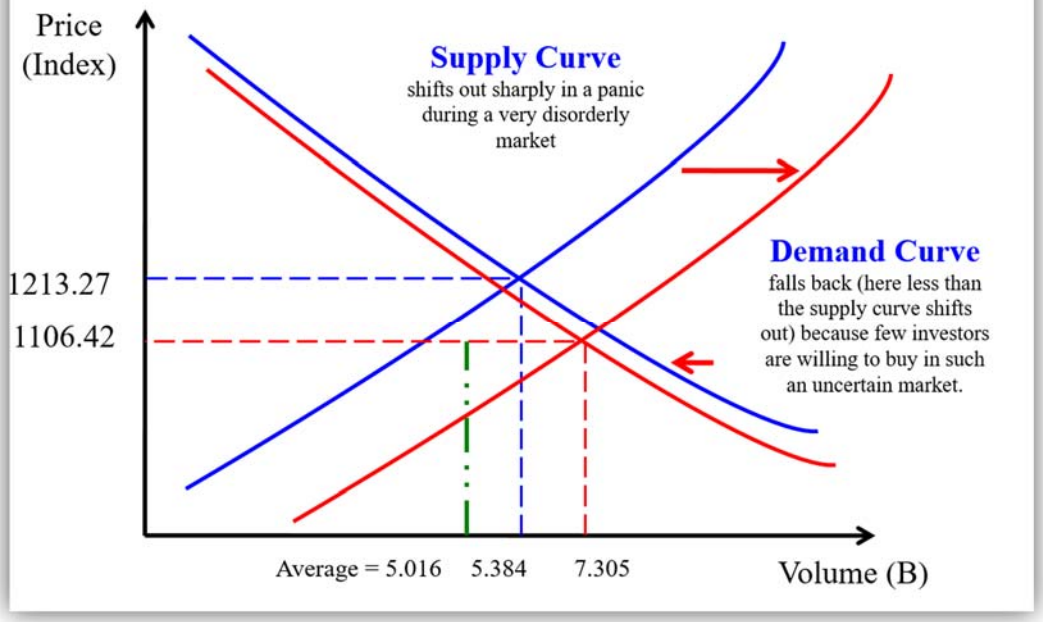
which did indicate a panic sell-off. **Figure 8** shows the peak and trough of this terrible cycle as measured by the **S&P 500** (here we are using the broader index), and **Figure 9** shows the huge increase in share volume (for the 500 stocks that make up that index) during that period, showing both daily data and data smoothed by a 110-day moving average.

Figure 9 – Daily Volume for the S&P 500 stocks and a 100-day moving average of the same, with an emphasis on the period between October 9, 2007 and March 9, 2009.



More typical of a supply-surge selloff would be the day represented by **Figure 10**, September 29, 2008, when the **S&P 500** fell **106.85** points, an amount equal to a staggering 8.8% of the index value (the **Dow** fell 777 points on the same day). On that day, again a Monday (and maybe there is a lesson in these Monday examples) volume swelled to 7.305 billion shares from 5.284 billion shares the previous Friday, in a year when daily volume averaged 5.018 billion shares for the stocks in the ***S&P 500***. As a note of information, this particular collapse was also a product of partisan rancor in Washington, this time during the final months of the Bush administration. The House of Representatives failed to pass a $700 billion financial rescue package (eventually to pass and to be known at **TARP 1**). And it wasn't the only news of the day. Rumors were circulating through the markets that several European banks needed government bailouts.

Figure 10 – (Actual) On Monday September 29, 2008 the S&P 500 has a record decline of 106.85, or 8.8% of its value, on a day which saw a surge in volume to 7.305 billion shares, on news that a $700 billion financial rescue plan failed a passing vote in the House of Representatives



Not too much should be made of this. Some of the highest volume days of 2008 saw little change in the index. For example, on October 10, 2008, a Friday, a volume record for the **S&P 500** was set at an astonishing 11.456 billion shares, but on that day the **S&P 500** index only fell 10.7 points to **899.22** (although on the following Monday it rose **104.13** points, a record). Obviously October 10 would be represented by **Supply** and **Demand** curves both shifting

out about the same amount, raising volume substantially but leaving the index value largely unchained. This was a wild day with no clear consensus among traders, with as many optimists (bulls) as pessimists (bears).

Looking back at **Figure 8** tells us that at that point the bears were right - the market as measured by the **S&P 500** index had another 25% to fall.

3. Supply and Demand Four-Quadrant Analysis

These examples above suggest that looking at patterns of price movement and volume for any individual stock or for the market as a whole represented by an index might prove useful. The circumstances that produce a rising price on rising volume, such as the impact upon **RHT** stock of the **IBM** acquisition effort shown in **Figure 5** are of an entirely different nature than those the produce rising prices on falling volume, such as the decline in the **DJIA** shown in **Figure 7.**

Figure 11 – Four-quadrant analysis, discussing likely scenario interpretations given the interactions between Supply and Demand the impact upon the Price and Volume pairing.

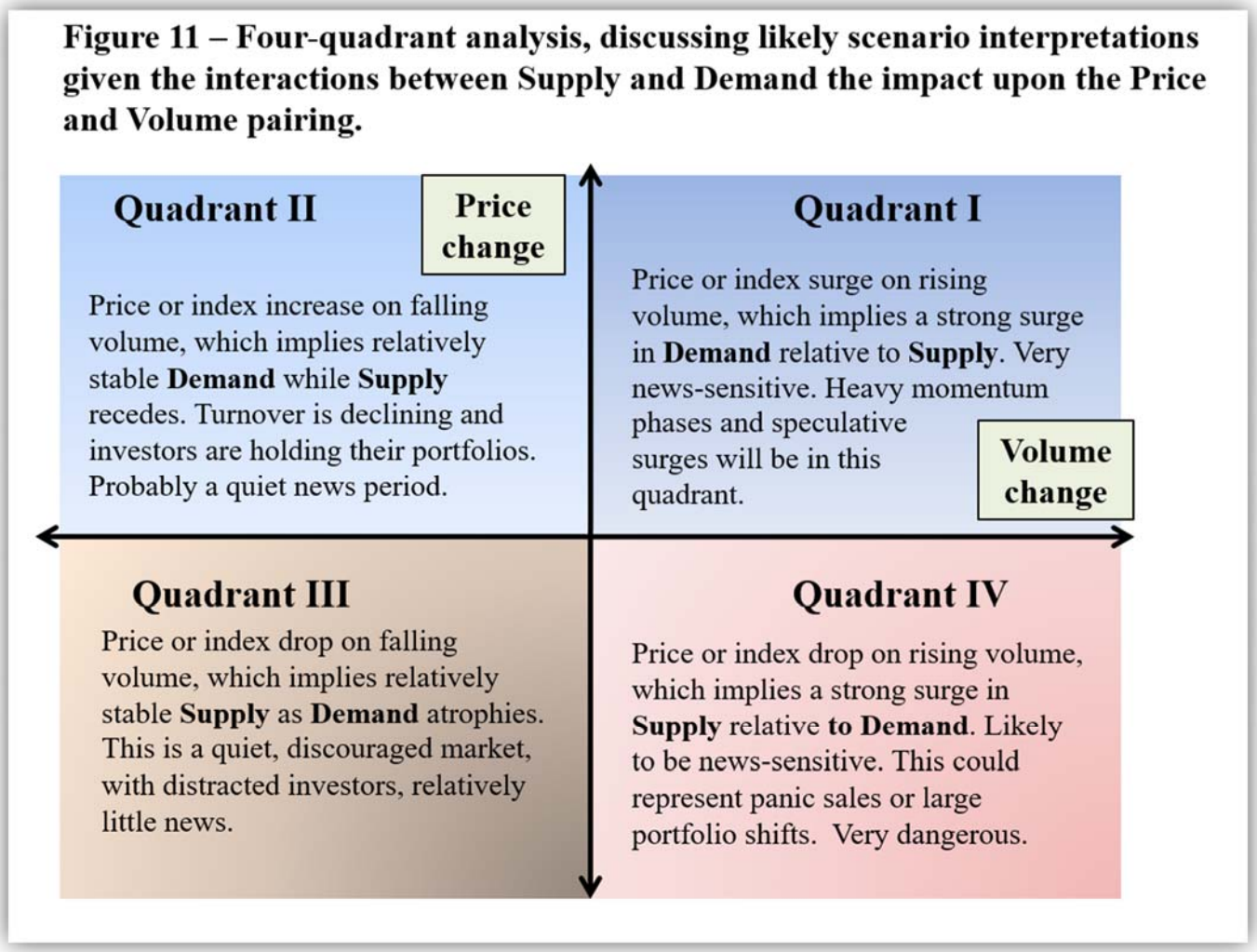


Figure 11 introduces four-quadrant analysis, which introduces scenario interpretations for the interaction between Supply and Demand and the impact upon the price and volume pair that are the result of that interaction.

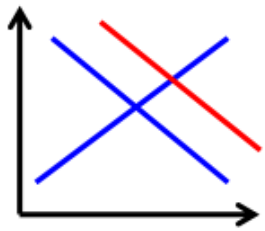
For example, read the entry in **Quadrant I** of **Figure 11. Quadrant I**, whether reflecting an index or an individual stock, represents the market circumstance where the Demand curve shifts out strongly, producing a rise in both price and volume. The **IBM** purchase of **RHT** as shown in **Figure 5**, represents a **Quadrant I** event.

Quadrant IV, on the other hand, represents a price decline on rising volume, which implies a large surge in **Supply** at a time of relatively stable **Demand.** If substantial and sustained, the phenomenon might represent panic selling in a very bearish market.

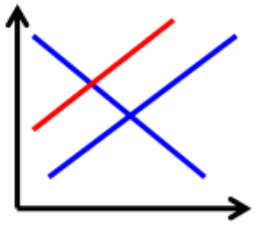
The term **Volume change** referred to on the abscissa of **Figure 11** is a relative term and will depend in part upon the market context where the analysis is being used. If referring to an index like the **S&P 500** for example, **Volume change** might refer to average volume for a number of days compared to an annual volume average for the same index, such as the kind of volume comparison that was done in **Figure 9.** The period discussed in **Figure 9,** from October 9, 2007 to March 9, 2009, was a **Quadrant IV** episode, a sharply declining market over a number of months of rising volume, *when comparing the 100-day moving average* to the longer-term average.

In reference to a single stock on the other hand, **Volume change** will either refer to an increase in volume today relative to yesterday or a high volume today relative to a recent average daily volume.

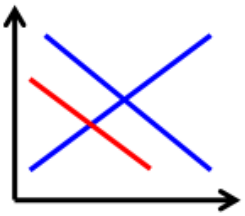
Although quadrant analysis is limited in what it offers, here are a few generalizations that can be made about these four trading patterns.



Quadrant I - With both rising prices *and* rising volume, this represent the ultimate bull market, the environment that makes most retail investors happy. If sustained, this kind of price activity is potentially very profitable for even the smallest traders. This type of behavior, if sustained over time, is at the root of *market momentum* and sometimes even *momentum ramps* and runaway markets (which will be discussed in the next chapter), especially if the price being represented is a major index. When this is a short-run phenomenon, especially in reference to a single stock over one or two days of trading, the shock that moves this market into **Quadrant I** might be a significant news event. Although this is obviously a lucrative environment it can be dangerous if one dallies too long in a long position. Extremes in **Quadrant I** warrant diligent attention.

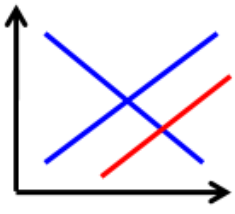


Quadrant II represents the happy prospect (usually) of rising prices, but in a quiet market with declining volume. For volume to be declining, **Demand** would have to be relatively stable while **Supply** is contracting. Remembering that **Supply** represents the potential selling activity of investors *who already own* the securities in question, this might represent a quiet period when investors are content with their existing portfolios, perhaps in part because they are earning dividends. Momentum markets and speculative bubbles - dangerous markets in general - are far less likely to be developing when markets are generally in this quadrant or near to ordinate axis (stable volume). This environment is typically less risky than **Quadrant I**, but also tends to be rather short-lived. Markets really don't tend to have sustained rallies in the face of declining volume.



Quadrant III also *usually* represents a quiet lackluster market. Potential sellers are relatively inactive, so **Supply** is stable, but **Demand** slowly decays for whatever reason, pulling down prices. If this is an individual stock the lack of interest is often because the company is doing nothing notable in earnings, or is not growing, and generally is attracting very little news interest. Poorly managed companies will often see their stocks in **Quadrant III** because the investing public is just losing interest. This is a very serious affliction for smaller companies because they have trouble generating news attention anyway, but can also afflict even the largest and most recognizable names like Microsoft and Cisco if the companies appear to be stagnant in their technology or market development.

When referring to indexes on the other hand, **Quadrant III** behavior can be seen during troubling times when markets are very much in the news. **Figure 7**, which showed the **S&P 500** falling sharply on a day of very low volume after the downgrade of U.S. Treasury long-term debt is one such example. Sometimes the demand atrophy can be attributed to the temporary absence of high-volume institutional traders, including algo traders, who disappear from the markets (essentially disappear from the bid queues), even if only for a few hours, during times of extreme uncertainty or duress.



Finally, **Quadrant IV** represents the dreaded crashing market. Those who have stocks want to sell them, and although there is demand, buyers are bargain hunters, willing to buy only at prices that are depressed relative to recent prices. This is how bubbles and other momentum markets end, rising volume and falling prices. This perfectly represents the

terrible bear market that was discussed above in **Figure 9** and **Figure 10**. When prices begin to stabilize after one of these bear episodes, it will usually be accompanied by gradually declining volume.

4. Using a Book Viewer to Construct the Supply and Demand Curve

We will conclude this chapter with an interesting exercise. We will use information from a complete limit order book to construct the unexercised portion of a supply and demand curve.

Figure 12 – IB limit order book for AMD

Bid				Ask			
MM Name	Price	Size	Cum Size	MM Name	Price	Size	Cum Size
AMEX	16.19	2	2	ARCA	16.20	46	46
ARCA	16.19	47	49	BYX	16.20	6	52
BYX	16.19	27	76	DRCTED...	16.20	17	69
DRCTED...	16.19	84	160	IEX	16.20	1	70
EDGEA	16.19	4	164	NSDQ	16.20	1	71
IEX	16.19	11	175	PSX	16.20	2	73
NSDQ	16.19	6	181	AMEX	16.21	2	75
NYSENAT	16.19	1	182	ARCA	16.21	48	123
PSX	16.19	85	267	EDGEA	16.21	5	128
ARCA	16.18	58	325	NSDQ	16.21	3	131
NSDQ	16.18	9	334	NYSENAT	16.21	4	135
ARCA	16.17	55	389	ARCA	16.22	53	188
ARCA	16.16	274	663	NSDQ	16.22	3	191
ARCA	16.15	148	811	ARCA	16.23	55	246
NSDQ	16.15	3	814	NSDQ	16.23	1	247
ARCA	16.14	59	873	ARCA	16.24	63	310
NSDQ	16.14	1	874	ARCA	16.25	55	365
ARCA	16.13	99	973	ARCA	16.26	58	423
ARCA	16.12	53	1,026	NSDQ	16.26	1	424
ARCA	16.11	46	1,072	ARCA	16.27	58	482
ARCA	16.10	265	1,337	NSDQ	16.27	3	485
ARCA	16.09	29	1,366	ARCA	16.28	35	520
ARCA	16.08	78	1,444	ARCA	16.29	30	550
ARCA	16.07	36	1,480	ARCA	16.30	25	575
ARCA	16.06	37	1,517	ARCA	16.31	27	602
ARCA	16.05	99	1,616	ARCA	16.32	28	630
ARCA	16.04	29	1,645	ARCA	16.33	26	656

Refer to **Figure 12**, which shows the Interactive Brokers book viewer for all limit orders for **AMD** at a moment in an August trading day in 2018. The **Bid** side represents all limit orders to buy, with Best Bid at the top. Given that, here is an interesting question: What is the total demand for **AMD** at the price of **$16.17**?

Although there are only 5,500 shares with bids at **16.17**, the answer is actually 38,900 shares (see the **Cum Size** column). We have to remember that the bids that we see at **16.17** are bids to buy at **16.17** *or better*, so those bidding **16.19** and **16.18** would certainly buy the stock if it was priced at **16.17**. Therefore, based upon this logic we can say that in this market the demand curve for **AMD** consists of the cumulative limit orders on the bid side of the queue.

By the same logic the cumulative asks calculated by going down the ask side of the queue (which is going up in price) allows us to construct a portion of a supply curve.

When these cumulative results are mapped (and the axis twisted) as has been done in **Figure 13**, we can see that we have captured the right half of the supply and demand curve image for the stock in question.

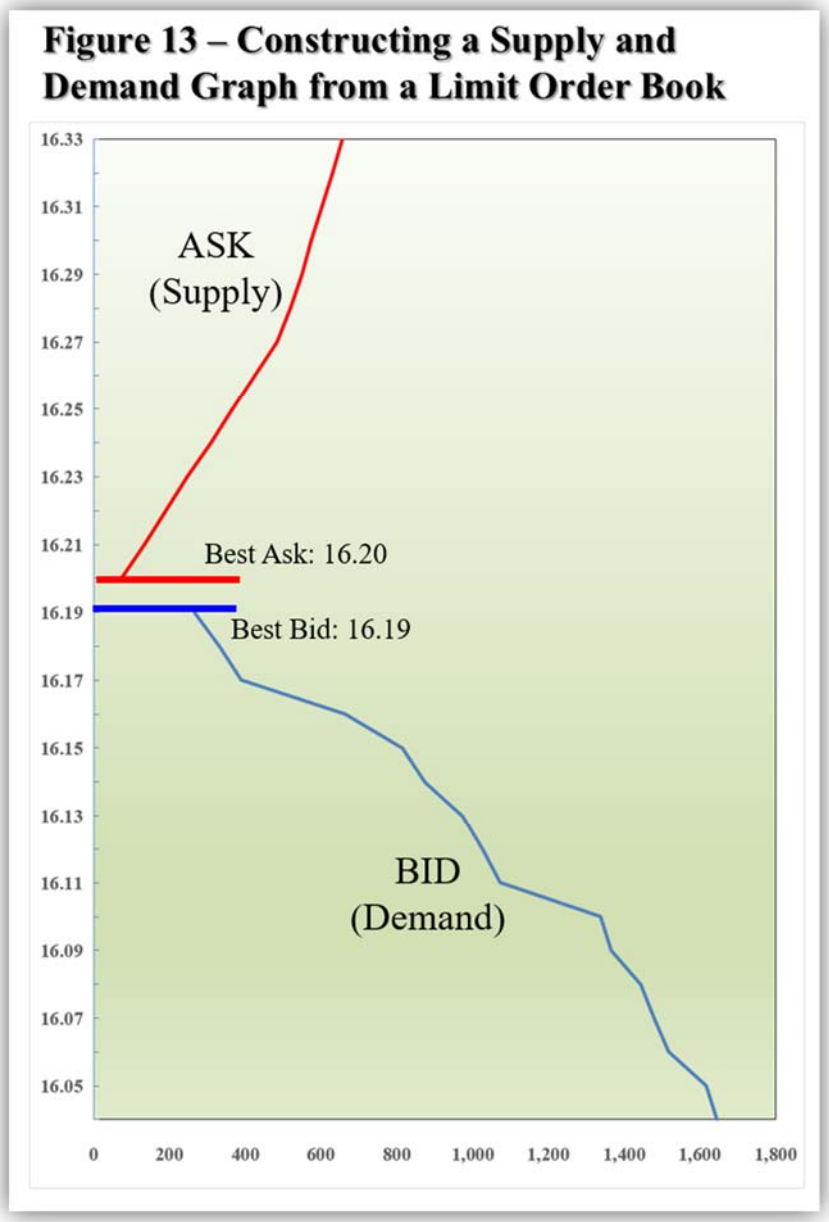
What does it represent? The right side of a supply and demand curve mapping can be thought of, at any moment, as the remaining *unsatisfied* components of supply and demand for this stock. All supply and demand on the left side was *cleared* by previous transactions.

For the moment this is just a curiosity. But some empirical modeling of this concept might actually produce some interesting implications. For example, in this case, by inspection, we can see that the supply curve (the red line) will be much more responsive to a sudden shift in demand than the demand curve (the blue line) would be to a sudden shift in supply. We can estimate, therefore, at this moment that supply is much more responsive to demand than demand is to supply. This revelation may have some useful implications for certain trading strategies.

More important, it reminds us analytically that underlying supply and demand conditions impacting a certain stock will be what ultimately determines the response of a stock's price to any outside phenomenon or shock to the system.

5. Using the Model to Explain Market Opening and Closing Auctions

Figure 13 – Constructing a Supply and Demand Graph from a Limit Order Book



The previous chapter had a lot to say about how limit orders and market queuing determine the pricing of stocks during normal business hours and this chapter leaves one with the impression that the process can be explained by the interaction of supply and demand. But nothing was said in the previous chapter about the opening price for each stock at the beginning of the trading day nor the closing price at the end of the day.

One might be left with the impression that the opening price is simply the first limit order that is executed and the closing price is perhaps the last limit order executed with a timestamp that precedes 4:00 PM New York time.

But that is not the way it works. Such a simple procedure would be very easy to manipulate by carefully timing high-speed orders. And the closing value for the day is especially important because, as we shall see in **Chapter 5 Mutual Funds,** a mutual fund's net asset value, which is the price at which investors must buy or sell the fund, is determined by the closing price of the stock or ETF in question.[4]

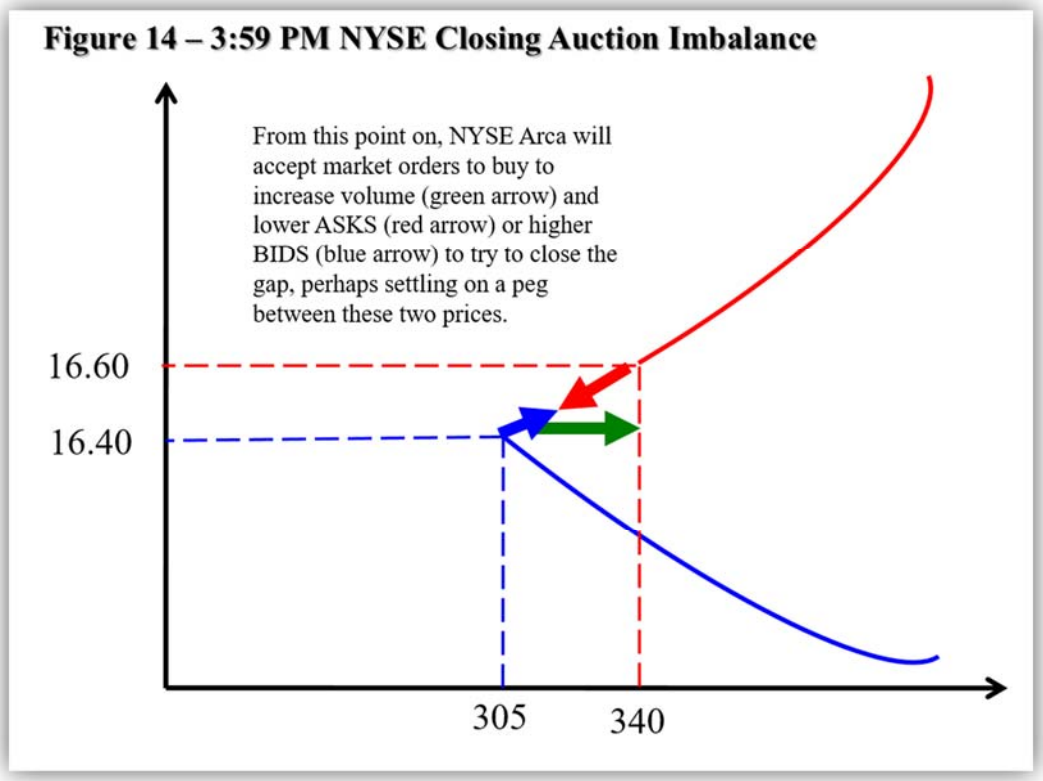
For stocks listed by **NASDAQ** or the **NYSE,** opening and closing prices are determined by a special auction. Although the procedure differs a little between the morning and evening auction and also between the way the NYSE does it compared to **NASDAQ**, the procedures are similar enough to generalize, but we will also use the **NYSE** closing auction as a specific example.[5]

Both exchanges accept specialized limit and market orders for the auctions. **NYSE Arca** accepts special orders called Market-On-Close (**MOC**) Orders and Limit-On-Close (**LOC**) Orders that are submitted specifically for the closing auction. Such orders can be submitted as early as 9:30 AM that morning, but most orders are submitted closer to the 4:00 PM close. **NYSE Arca** keeps a volume record at each limit order price and at 3:00 PM, an hour before the market close, the exchange publishes imbalance information in the hope of attracting more orders for filling any balance gaps. The imbalance is frequently updated until 3:59 PM. After that time, no orders can we withdrawn and no new limit or market orders are accepted *unless they serve to reduce the imbalance.*

[4] What this all means will, of course, be explained in Chapter 5.
[5] See "NYSA Arca Auctions." https://www.nyse.com/publicdocs/nyse/markets/nyse-arca/NYSE_Arca_Auctions_Brochure.pdf

Refer to **Figure 14,** where at 3:59 a hypothetical imbalance is shown (somewhat idealized). There is no limit order to sell below 16.60 and no limit order to buy above 16.40, and the lowest sell (ASK) order is at a volume considerably higher (340) than the highest buy (BID) order (305). At this point the exchange will accept *only* a lower sell limit order or a higher bid limit order (and reject any other orders) and will close the volume gap with market orders to buy. If no actual equilibrium is reached (rare) then a price that maximizes volume is reached at a peg somewhere between bid and ask.

Figure 14 – 3:59 PM NYSE Closing Auction Imbalance



6. Final Words

This chapter was meant to offer an elementary introduction to thinking about stock market performance in modeling terms. The usefulness of these models are of course limited. They tend to be a bit more useful for explaining what has already happened rather than what might happen next, and we are usually a lot more interested in the latter than the former.

Likewise, the model has little to say about market *volatility*, the tendency of these prices oscillate back and forth, sometimes savagely, between gains and losses.

But the model is valid to some degree, because these are truly competitive markets and in such markets prices do reflect the ebb and flow, even when volatile and erratic, of supply and demand, or competition between players on the buying side and the selling side.

As stated in the introduction to this chapter, little was said about the *variables* (like corporate earnings) that affect supply and demand. We will cover that subject in **Chapter 4**.