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Webinar Handout

Webinar Title: The Market Derived Blockage Discount Model

Presented by: William H. Frazier, ASA | Ronak P. Shah, CFA

Webinar Description: Determining blockage discounts by the Black Scholes Option Model has been a common practice for over twenty years. Blockage is defined by the cost of buying enough put options to hedge the price of the subject shares on the valuation date. One weakness with this approach has been the holding period for the options. In most cases, this has been determined by unsupported assumptions. The Market-Derived Blockage Discount Model presents a mathematical means for determining the appropriate selling period for the subject shares in a blockage ''dribble out'' analysis. If the model assumes too many shares are sold at one time, the price impact is too great. If the dribble out period is too long, the cost of the option is too high. Additionally, the shares to be sold in the hypothetical selling period of the model will increase the volatility input needed for the model. The optimum option holding period is the one that achieves the lowest cost.

Learning Outcomes:
Upon webinar completion, the participant will:

- Recognize the strength and weaknesses of the traditional option model method for determining blockage discounts;
- Determine objectively the optimum holding period for the option model;
- Test how the sale of the block affects volatility; and
- Analyze the relative costs of hypothetical price effect of the sale of shares with the cost of the purchasing put options.

WEBINAR SURVEY LINK: https://www.surveymonkey.com/r/TV6PK56

The Market-Derived Blockage Discount Model

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The Market Derived Blockage Discount Model

Blockage Discounts for Estate and Gift tax Purposes

IRS Estate Tax Regulations (Section 20.2031-2(e))

- size of the block in relation to the number of shares changing hands in “sales”
- If block is so large it could not be liquidated
  - in a reasonable time
  - without depressing the market
- the price at which the block could be sold as such ***outside the usual market***
- may be a ***more accurate*** indication of value

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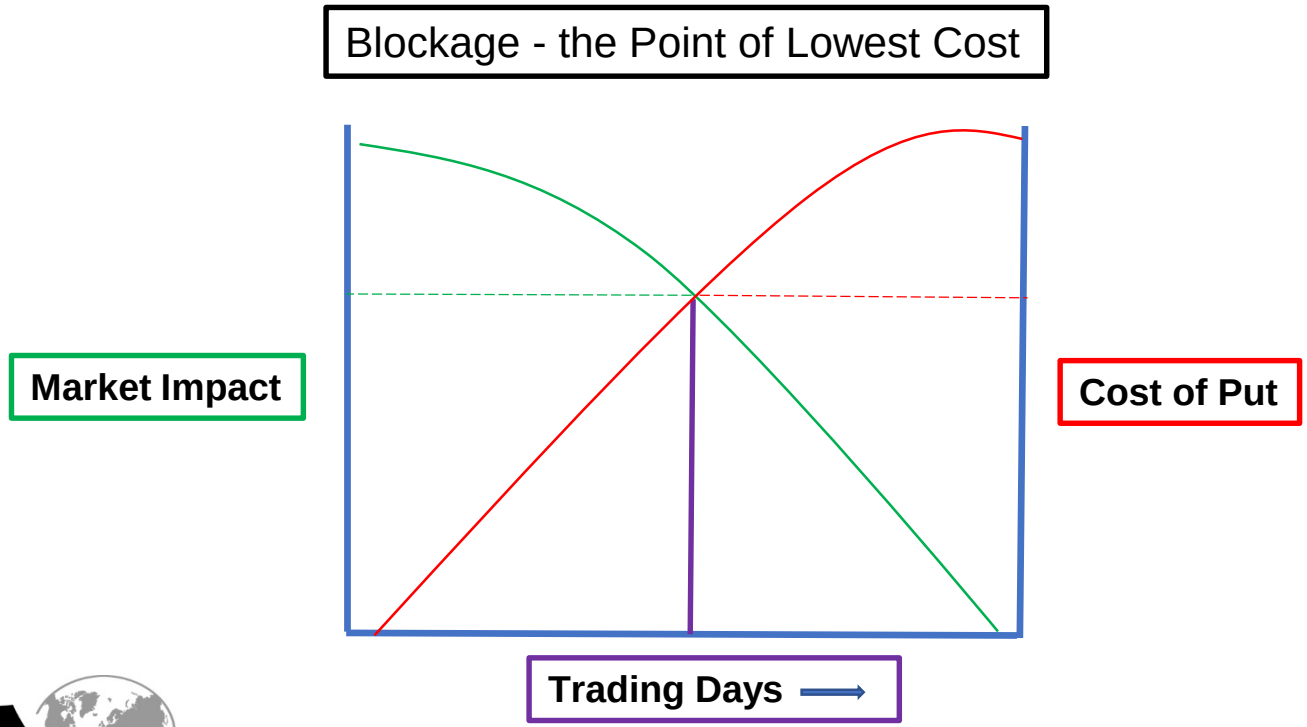
The Market Derived Blockage Discount Model



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Components Analyzed by MDBD

- Block size
- Volatility
- Effect of market on daily price and volume
- Price change in excess of market
- Big News days are omitted

MDBD's Use of Component Data

- Regression of excess (unexplained) price change to daily volume
- Scenarios for a number of possible selling period are examined
- Volatility of selling periods calculated
- Cost of put determined by BSOPM
- Selling period with lowest cost is the answer

Overview of the Model

Date	Volume	Adj Close	Daily Returns	DPC Absolute Value of r (Daily Price change)	ADV Recent Avg. Daily Volume ("ADV")	SDPC Standard Deviation of Price Change	EV Excess Volume	EC Excess Daily Price Change	DTV Multiple of Volume to Recent Average
06/26/15	892,274	66.05	-0.06%	0.06%	304,943	0.4%	587,331	-0.4%	2.93
09/01/15	779,095	65.61	-3.46%	3.46%	324,379	0.8%	454,716	2.7%	2.40
05/08/15	772,750	65.08	-1.39%	1.39%	338,300	0.4%	434,450	1.0%	2.28
06/29/15	735,376	65.36	-1.04%	1.04%	304,955	0.5%	430,421	0.6%	2.41
02/04/15	713,572	62.44	-1.08%	1.08%	294,740	0.7%	418,832	0.4%	2.42
10/15/14	742,660	54.01	2.31%	2.31%	336,166	0.7%	406,494	1.6%	2.21
12/19/14	724,985	63.24	-0.24%	0.24%	330,678	0.4%	394,307	-0.2%	2.19

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Overview of the Model

5 Input Days in Group			
Sum(EC)	Group EC	Sum(DTV)	Group(DTV)
1.2%		3.87	
4.8%		7.55	
4.4%		10.47	
4.4%		12.45	
6.9%	1.4%	14.67	2.93
0.6%		2.41	
0.4%		4.64	
0.2%		6.78	
0.6%		9.22	
0.9%	0.2%	11.35	2.27
0.3%		2.08	
3.1%		4.29	
3.7%		6.33	
3.4%		8.20	
3.2%	0.6%	10.17	2.03

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The Market Derived Blockage Discount Model

Overview of the Model

Price Change Group [a]	Average Excess Price Change	Average Days Trading
1	1.4%	2.93
2	0.2%	2.27
3	0.6%	2.03
4	0.4%	1.87
5	0.5%	1.52
6	0.8%	1.59
7	0.2%	1.39
8	-0.4%	1.43
9	0.8%	1.39
10	0.7%	1.32
11	-0.2%	1.18
12	0.4%	1.08
13	-0.1%	1.19
14	0.8%	1.13
15	0.0%	1.01
16	0.4%	0.98
17	0.3%	1.01
18	-0.2%	1.06
19	0.1%	1.01
20	0.9%	0.95

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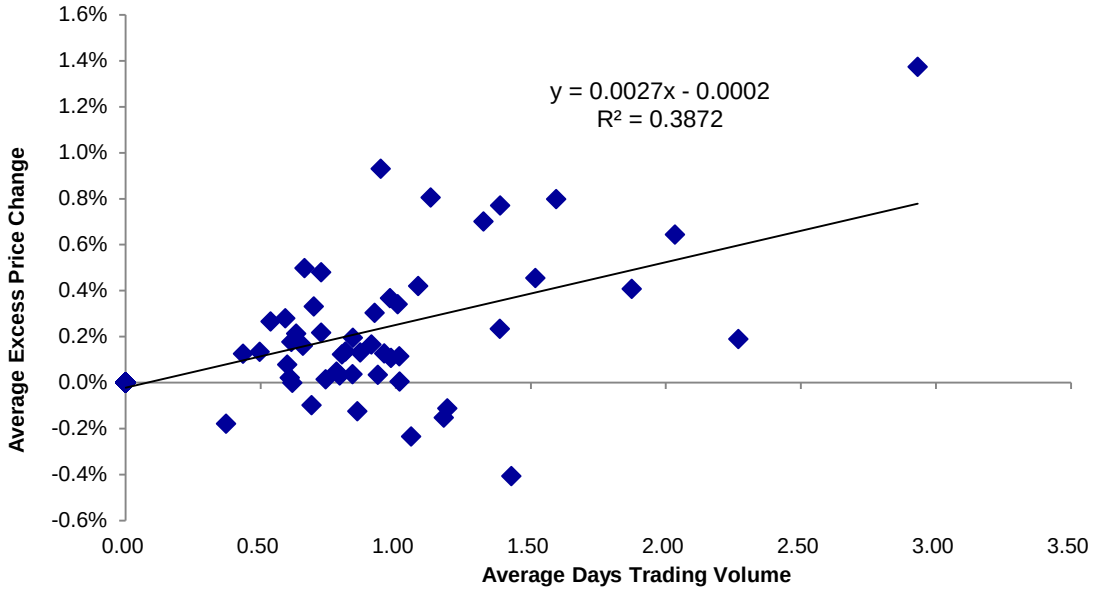
The Market Derived Blockage Discount Model

Overview of the Model



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Overview of the Model

Block Size	1,016,710
Excess shares ratio (Days trading of Group)	1.55
Avg Daily Volume	371,866
Implied volatility	26.27%
Indicated Group Price Decline	0.42%
Indicated number of shares traded	575,208
Excess Shares (indicated less average shares)	203,342
Indicated Dribble out Days	5.0
Weighted Average Dribble Out Days	2.5
Adjusted Volatility	33.0%

The Blockage Discount is a Cost

To avoid a blockage discount a seller may break his purchases down into smaller lots.

- requires a greater number of transactions
- adds to cost of sale
- adds to the risk of market exposure.

Use of Black Scholes in MDBD

- MDBD defines “reasonable time” as a mathematically determined optimum selling point in a hypothetical plan to sell a block of shares.
- The objective in any program to sell shares in the marketplace is to achieve the **highest net price** possible.

Use of Black Scholes in MDBD

- If too many shares are sold relative to the demand, the price will be affected negatively.
- If too few shares are sold and the selling period is extended over a very long period, the cost of the put will be high.

Volatility

- The model also estimates how the hypothetical trade, itself, might affect the volatility of the underlying shares during the selling period.
- This latter assumption is of major importance to the seller of the put and informs his pricing analysis.
- Most blockage models used today omit this step by simply using historical or implied stock price volatility.

Volatility

- Expectation during the holding period.
- Writer will want to calculate the cumulative effects on the market price as shares hit the market each day of the selling period.

Polling Question Number 1

Blockage Discounts for Estate and Gift tax Purposes

Why do we need a blockage model?

Weaknesses of Existing Methods

Do not explain “reasonable period of time”

Usually cite heresay

- Management said that market maker said
- The market maker said
  - No study, letter or report
  - No testimony

Weaknesses of Existing Methods

Calibration is often wrong

- Set the holding period to “no effect” of the market place
  - Unnecessarily increases the holding period
- Pick arbitrary selling volume
  - “2 times daily volume”
  - Why?

Weaknesses of Existing Methods

Failure to account for change in volatility

- Multiple successive days of high volume

Myopic view of historical trading and pricing

- Effect of the market as a whole
- Company

Blockage in the United States Tax Court

"Blockage is not a rule of law, but a question of fact. If the price obtainable for a block of stock is influenced by the size of the block, the existence and extent of this influence must be proven."

Safe Deposit & Trust Co. of Baltimore, Executor [Dec. 9549], 35 B.T.A. 259-263 (1937), affd. [38-1 USTC ¶ 9240] 95 F.2d 806 (C.A. 4, 1938)

The Market Derived Blockage Discount Model

Blockage in the U.S. Tax Court

Art

Estate of Elkins v. Commissioner, 140 T.C. 86 (2013)

Estate of Elkins v. Commissioner, (5th Circuit)

Estate of Georgia O'Keee v. Commissioner

Estate of de Kooning et al. v. Commissioner

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Blockage in the U.S. Tax Court

Real Estate (‘market absorption”)

- Astleford v. Commissioner
- Estate of Auker V. Commissioner
- Estate of Rodgers v. Commissioner
- Carr v. Commissioner
- Estate of Grootemaat v. Commissioner

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Blockage in the U.S. Tax Court

Common Stock

- Foote v. Commissioner
- Estate of Murphy v. United States
- Estate of Gimbel v. Commissioner
- Litman v. United States
- Estate of Davis v. Commissioner

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MDBD is not DLOM

Most blockage cases are really about the Discount for Lack of Marketability (DLOM)

- Restricted stocks
- Holding Period
- Dribble out selling period

MDBD is not DLOM

Holding/Selling Periods* of restricted stocks in blockage cases

- Gimbel - 3.25 years
- Litman - 4 years
- Davis – 6 months
- Murphy – 1 year (Deltic restricted stock)

*elapsed time, not weighted average

Foote v. Commissioner

Mr. Davis properly considered the relevant factors:

1. The relative size of the Trust's block of stock in relationship to the number of shares of stock outstanding,
2. the ownership of other blocks of stock,
3. current and historical trading volumes of [the] stock, and
4. recent company-specific events.

Mr. Davis also reviewed general economic conditions and securities market trends and sentiment.

Foote v. Commissioner

- "Respondent complains that…[the taxpayer's expert's] calculation… was determined by using 18 selected blockage discount tax cases.
- We also find fault with this approach
- Each case is different, and the determination of a blockage discount, if any, depends upon the particular facts and circumstances involved"

The Market Derived Blockage Discount Model

Tax Court in *Estate of Gimbel* rejected an option model

"With respect to the put options used by Range in his **dribble-out analysis**, we believe the testimony of Kimball that an active market did not exist for put options on the estate's Reliance shares.

In order for the estate to purchase put options on its Reliance shares, **the estate would have to find a party willing to write nonstandard, nontraded put options**.

Even if a writer of put options on Reliance stock could be found, the writer would require a substantial premium due to the inability to unwind its position by purchasing opposite call options in the open market and due to other associated market risks."

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The Market Derived Blockage Discount Model

Tax Court in *Estate of Davis* rejected BSOPM

Petitioner's expert Mr. Howard and respondent's expert Mr. Thomson agree that ADDI&C probably would have sold its Winn-Dixie stock pursuant to the dribble-out method.

Although respondent's expert Mr. Thomson acknowledges that ADDI&C's Winn-Dixie stock was subject to the SEC rule 144(e)(1) volume limitation… he did not discount [because] Winn-Dixie's NYSE price "was on a rising trend line"…

The Market Derived Blockage Discount Model

Tax Court in *Estate of Davis* rejected BSOPM

Nor did Mr. Thomson apply a premium to the NYSE price because…even though ADDI&C owned 1,020,666 shares of the outstanding Winn-Dixie stock, Mr. Thomson considered that block of stock, which represented only about 1.33 percent of the total outstanding shares of Winn-Dixie, to be "too small" to represent a "swing block of shares.“

It is noteworthy that petitioner's expert Mr. Pratt acknowledges that ADDI&C's stock interest in Winn-Dixie on the valuation date "is generally considered to be a significant investment. An investor would likely find it difficult to quickly accumulate such a large investment without some…[upward effect] on the quoted market price..."

The Market Derived Blockage Discount Model

Tax Court in *Estate of Davis (1998)* rejected BSOPM (contd.)

"Mr. Howard determined in his rebuttal report that a 4.9- percent blockage and/or SEC rule 144 discount should be applied to Winn-Dixie's NYSE price on the valuation date in determining the fair market value of ADDI&C's Winn-Dixie stock and its net asset value on that date. He arrived at that percentage discount based on the Black- Scholes options pricing model

Respondent argues that use of the Black-Scholes model will always result in a blockage and/or SEC rule 144 discount. Mr. Howard agrees, and so do we. "

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Polling Question Number 2

The Market Derived Blockage Discount Model

Litman v. United States (2007)

"Mr. Mitchell applied two quantitative methods to directly calculate the marketability discounts using theoretical models: the Black-Scholes option pricing model and the capital asset pricing model."

"The most persuasive real-world factor supporting Mr. Mitchell's methodology is the fact that Ruth Haney, IRS valuation agent, used an option-discount methodology…"

The Market Derived Blockage Discount Model

Federal District Court in *Estate of Murphy (2009)* accepts BSOPM

Murphy Opinion cites *Litman v. United States, 78 Fed. Cl. 90, 146 (2007)*

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Option Collar Methodology Rejected

Litman v. United States-

"Mr. Mitchell argued and the court agrees that because the collar relies on real-world variables, it cannot be considered theoretical."

Murphy –

"Burns then used an approach (an option collar approach) in determining the discount on the 310,922 restricted shares of Deltic stock that has previously been rejected [(*Litman*)]"

The Market Derived Blockage Discount Model

The Use of Black Scholes Option Pricing Model

- BSOPM has been accepted, although not always, by both the Delaware and US Tax Courts.
- CAPM and beta have their flaws, they are often accepted by the courts.
- Finnerty and Abbott both propose models which are described as superior to BSOPM.

Pure Blockage

Barker determined the blockage discount on the 119,475 **unrestricted shares** of Deltic by considering:

- the **size of the block** of stock relative to the daily trading volume,
- the **volatility** of the stock,
- the price change in the stock under recent and preceding market conditions,
- the company's current economic outlook,
- the trend of the price and the financial performance of the stock,
- the trend of the company's earnings
- the existence of any **resale restrictions** on the stock.

The Use of Black Scholes in “Pure Blockage”

- Mechanics of blockage sale transaction are very different from restricted stock analysis
- The holding period in DLOM is measured in months or years.
- The holding period in blockage is usually a matter of a few days.

Blockage is not DLOM

- Restricted stock analysis has both
  - “holding period” and
  - “selling period.”
- Depending upon the size of the block, it might also encounter illiquidity costs as it is being liquidated in the open market (blockage)

Criticisms of BSOPM

- Overprices long dated options - not relevant for a blockage analysis
- Misprices options which are deeply in-the-money and out-of-the-money.
- We are assuming an at-the-money option
- Uses a constant volatility.
- The MDBD attempts to correct for this by dynamically increasing volatility

Dark Pools

- Some block trades are conducted through “dark pools”.
  an Alternative Trading System (“ATS”)
  - private securities trading platform
  - participants execute large block trades
  - delayed public disclosure.
- price of a given security stays relatively stable as the order is filled.

Dark Pools

- Very large trades are rare on both dark ATSs and lit exchanges.
- The modal trade size on both lit exchanges and dark ATSs is 100 shares.

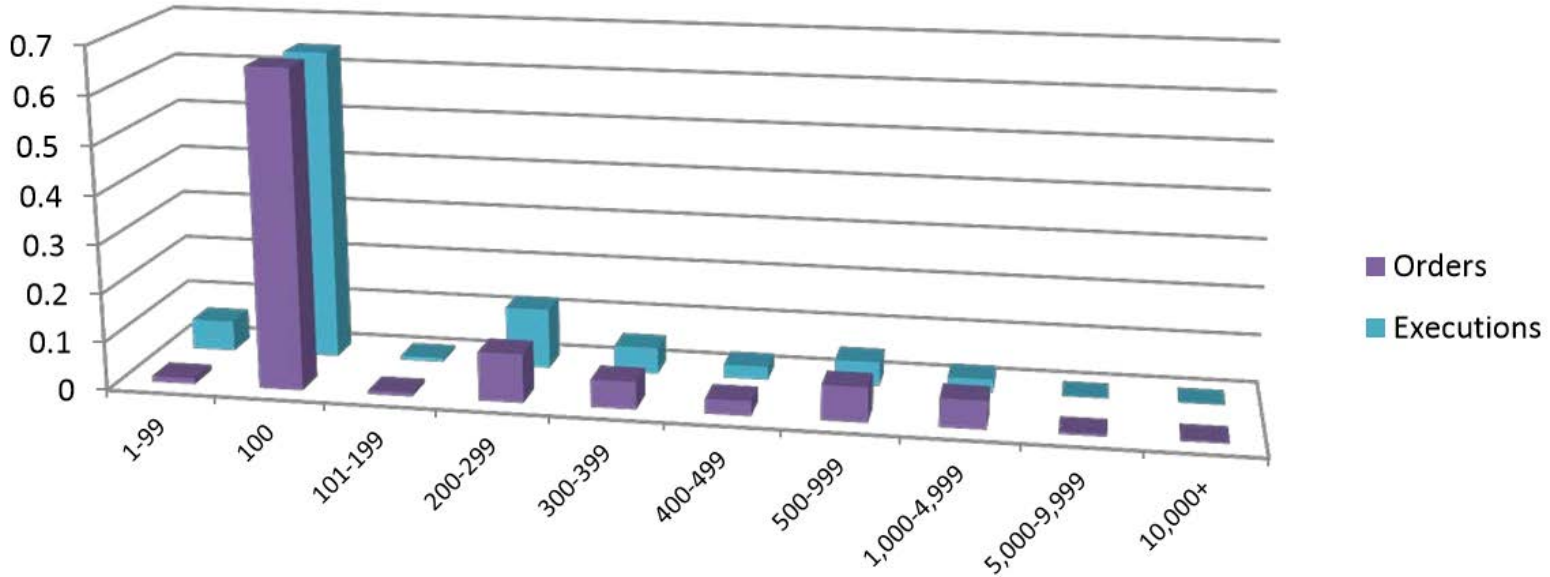
Laura Tuttle. *Alternative Trading Systems: Description of ATS Trading in National Market System Stocks*. Securities & Exchange Commission-Division of Economic and Risk Analysis. October, 2013.

Dark Pools

"Although some dark ATS trading likely results from the shredding of larger orders into smaller units for execution over time, the similarity between lit exchange and dark ATS trade sizes does not appear to support the characterization of dark ATSs as venues specializing in block transactions."

Laura Tuttle. Alternative Trading Systems: Description of ATS Trading in National Market System Stocks. Securities & Exchange Commission-Division of Economic and Risk Analysis. October, 2013.

Dark Pools



Laura Tuttle. Alternative Trading Systems: Description of ATS Trading in National Market System Stocks. Securities & Exchange Commission-Division of Economic and Risk Analysis. October, 2013.

Dark Pools

Venue Type	N	Dollar Volume (MM)	Proportion of Dollar Volume (%)
Agricultural	2	1	0.00%
Credit / Fixed Income	8	24,158,681	44.86%
Derivative	6	27,486,746	51.04%
Specialized Assets	6	24,061	0.04%
Private Securities	2	364	0.00%
NMS Securities	45	2,181,183	4.05%
Total	69	53,851,036	100.00%

Laura Tuttle. Alternative Trading Systems: Description of ATS Trading in National Market System Stocks. Securities & Exchange Commission-Division of Economic and Risk Analysis. October, 2013.

Dark Pools

- dark pool trading is not useful in determining the fair market value of a block as of a certain point in time.
- do not provide a record of the information required to assess the market impact of volume.

Polling Question Number 3

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Determining Market Impact

- expected market price effect of the additional daily volume (supply) created by the sell order(s)
- daily marginal increase in volume affects the stock price
- the market for any stock operates by the law of supply and demand

Determining Market Impact

- Including the effects of this fundamental valuation changing transaction in an empirical analysis of the stock's expected price-volume relationship would cause distortion**.**

Determining Market Impact

- Days in which the price is affected by volume not caused by a specific event which alters the fundamental value premise of the stock.
- This type of volume fluctuation is termed “idiosyncratic” since it is random and unpredictable.

Determining Market Impact

- Price changes are mainly driven by the order flow imbalance,
- A recent academic study documents a linear relation between order flow imbalance and price changes, with a slope inversely proportional to the market depth.

- Cont, Rama, Kukanov, Arseniy and Stoikov, Sasha. *The Price Impact of Order Book Events.* Journal of Financial Econometrics (2013). Available at SSRN: http://ssrn.com/abstract=1712822 or http://dx.doi.org/10.2139/ssrn.1712822.

Determining Market Impact

- In other words, the greater the stock's depth, the more additional volume it takes to affect the daily market price and, vice versa.
- The point of this paper is to determine a method to estimate the expected price response to a large and unexpected "sell" order.
- In our opinion, a solution can be estimated by an analysis of the stock's price-volume history.

Determining Market Impact

- The role of the writer (seller) of the put option is central
- impossible for the hypothetical block seller to actually go into the option market and buy contracts
- In many cases, publicly-traded options on the subject stock do not exist.

Determining Market Impact

- Assume a 10 day dribble out period
- 10 separate put contracts are required
- The duration of the puts will vary from one day to ten days.
- Puts with sequential daily durations do not exist even for stocks with publicly-traded options.

Determining Market Impact

- Option contracts written for blockage purposes must be specially written by a financial intermediary
- We can assume that the put writer would be fully informed about the plans of the block holder to sell its shares.
- This idiosyncratic increase in the stock's volatility would be factored into the put writer's pricing.

Determining Market Impact

- The holder of the shares is insulated from price declines during the dribble out period by virtue of the put option contract,
- However, since the seller of the put option is not insulated from price volatility will face much greater volatility factored into the pricing of the put

Polling Question Number 4

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Determining Market Impact

- The model begins with a look at one year of:
  - stock prices
  - volume (daily and average)
  - price changes

Determining Market Impact

- A “high volume day” is defined as a day when the volume is greater than the mean of the previous 30 days on a rolling basis.

- The price change used for blockage purposes:
  - high volume days
  - Price change > 1 s.d. above the mean price change.

Determining Market Impact

- Identify and eliminate high volume days that appeared to be influenced by major events
  - Mergers & Acquisitions
  - Financings (debt and equity)
  - Contracts
  - Other

Determining Market Impact

- Excess Price Change - The Key Variable
- Examine the difference between the absolute value of the daily price change and the average daily expected price change.

Determining Market Impact

- Higher than normal volumes associated with a higher than normal price change.
- MDBD tests to see if this is true for the particular stock and block being examined.
- A regression formula for extrapolating the price impact for a given volume of trading in the stock.

Determining Market Impact

- We also examine the relationship of each day's trading volume to the recent average.
- If the difference between the day's volume and the average is positive or negative, we call this either excess or deficient volume.
- This excess (deficient) volume can expressed as a percent of the recent average daily trading volume.
- This ratio is called "Days Trading Volume," or "DTV."

Determining Market Discounts

An anticipated question here is the reason to use a standard deviation on an absolute value since the result of the standard deviation equation is always a positive number.

The answer is found in the standard deviation equation:

$$s = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \overline{x})^2}{N-1}}$$

Determining Market Discounts

- The result is derived from the absolute values of the daily difference of the mean.
- The mean, however, is derived from the sum of the pluses and minuses observed over the time period.
- Thus, the standard deviation of price changes over the past 30 days includes the net impact of both positive and negative changes.

Determining Market Discounts

- We are measuring the amount of price change determined by a given volume of shares traded.
- We do not care whether the price change is positive or negative.
- For this reason we use the absolute value of the change as our measuring statistic.

Chordia, Tarun, and Subrahmanyam, Avanidhar and Roll, Richard, Market Liquidity and Trading Activity (July 25, 2000). Eleventh Annual Utah Winter Conference. Available at SSRN: http://ssrn.com/abstract=237674 or http://dx.doi.org/10.2139/ssrn.237674. P.27.

Determining Market Discounts

- If we assume that prices are log-normally distributed, the characteristics of “down” days are the same as “up” days.
- That is, if we consider a mean price, the distribution of prices below the mean will mirror the changes in prices above the mean.

Determining Market Discounts

Some academics question this assumption, implying that sell-side effects are magnified relative to buy-side.

See, for example: Brennan, Michael J. and Chordia, Tarun and Subrahmanyam, Avanidhar and Tong, Qing, Sell-Order Illiquidity and the Cross-Section of Expected Stock Returns (March 7, 2012). Journal of Financial Economics (JFE), Forthcoming. Available at SSRN: http://ssrn.com/abstract=1396328. If the authors' assertions are correct, then, the model we show here will tend to understate the expected blockage discount.

The Market Derived Blockage Discount Model

Date	Volume	Adj Close	Daily Returns	DPC Absolute Value of r (Daily Price change)	ADV Recent Avg. Daily Volume ("ADV")	SDPC Standard Deviation of Price Change
07/28/14	190,505	59.59	-0.22%	0.22%	n.a.	n.a.
07/29/14	264,990	59.11	-0.81%	0.81%	n.a.	n.a.
07/30/14	214,758	59.72	1.03%	1.03%	n.a.	n.a.
07/31/14	260,408	58.35	-2.29%	2.29%	n.a.	n.a.
08/01/14	408,610	58.36	0.02%	0.02%	n.a.	n.a.
08/04/14	389,284	58.92	0.96%	0.96%	n.a.	n.a.
08/05/14	277,417	58.27	-1.10%	1.10%	n.a.	n.a.
09/01/15	779,095	65.61	-3.46%	3.46%	352,087	1.0%
09/02/15	560,811	66.90	1.97%	1.97%	351,321	1.1%
09/03/15	476,769	67.47	0.85%	0.85%	365,469	1.1%
09/04/15	210,954	66.44	-1.53%	1.53%	370,895	1.1%
09/08/15	345,925	68.35	2.87%	2.87%	374,609	1.1%

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Excess Price Change

EC		DPC		SDPC
Excess (Deficient) Daily Price Change	=	Absolute Value of Daily Price Change	−	Standard Deviation of Price Change

Excess Price Change

Date	DPC Absolute Value of r (Daily Price change)	SDPC Standard Deviation of Price Change	EC Excess Daily Price Change
06/26/15	0.06%	0.4%	-0.4%
09/01/15	3.46%	0.8%	2.7%
05/08/15	1.39%	0.4%	1.0%
06/29/15	1.04%	0.5%	0.6%
02/04/15	1.08%	0.7%	0.4%
10/15/14	2.31%	0.7%	1.6%
12/19/14	0.24%	0.4%	-0.2%

Days Trading Volume

DTV		DV		ADV
Multiple of Volume to Recent Average	=	Daily Volume	/	Recent Average Daily Volume (30 days)

Days Trading Volume

Date	Volume	ADV Recent Avg. Daily Volume ("ADV")	DTV Multiple of Volume to Recent Average
06/26/15	892,274	304,943	2.93
09/01/15	779,095	324,379	2.40
05/08/15	772,750	338,300	2.28
06/29/15	735,376	304,955	2.41
02/04/15	713,572	294,740	2.42
10/15/14	742,660	336,166	2.21
12/19/14	724,985	330,678	2.19

Polling Question Number 5

Selling period scenarios

Excess (Below) Volume	EC Excess(deficiency) Daily Price Change	Days' Trading Vol. Multiple of Volume to Recent Average	5 Input Days in Group			
			Sum(EC)	Group EC	Sum(DTV)	Group(DTV)
969,297	1.2%	3.87	1.2%		3.87	
841,805	3.6%	3.68	4.8%		7.55	
587,331	-0.4%	2.93	4.4%		10.47	
440,016	1.0%	2.32	5.3%		12.80	
430,421	0.6%	2.41	5.9%	1.2%	15.21	3.04
(213,841)	0.3%	0.47	0.3%		0.47	
(216,364)	-0.3%	0.35	0.0%		0.81	
(217,320)	-0.2%	0.34	-0.3%		1.16	
(231,727)	-0.3%	0.32	-0.6%		1.48	
(239,240)	-0.1%	0.41	-0.7%	-0.1%	1.89	0.38

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The Market Derived Blockage Discount Model

Selling periods

-10 Day Groups
-Highest DTV to Lowest

10 Input Days in Group			
Sum(EC)	Group EC	Sum(DTV)	Group(DTV)
-0.4%		2.93	
2.3%		5.33	
3.3%		7.61	
3.9%		10.02	
4.3%		12.44	
5.9%		14.65	
5.7%		16.85	
5.7%		18.82	
5.5%		20.97	
6.1%	0.6%	23.14	2.31
2.9%		2.20	
3.1%		4.48	
3.5%		6.56	
4.1%		8.60	
4.8%		10.63	
4.6%		12.61	
4.4%		14.48	
4.7%		16.43	
5.7%		18.16	
6.9%	0.7%	19.81	1.98

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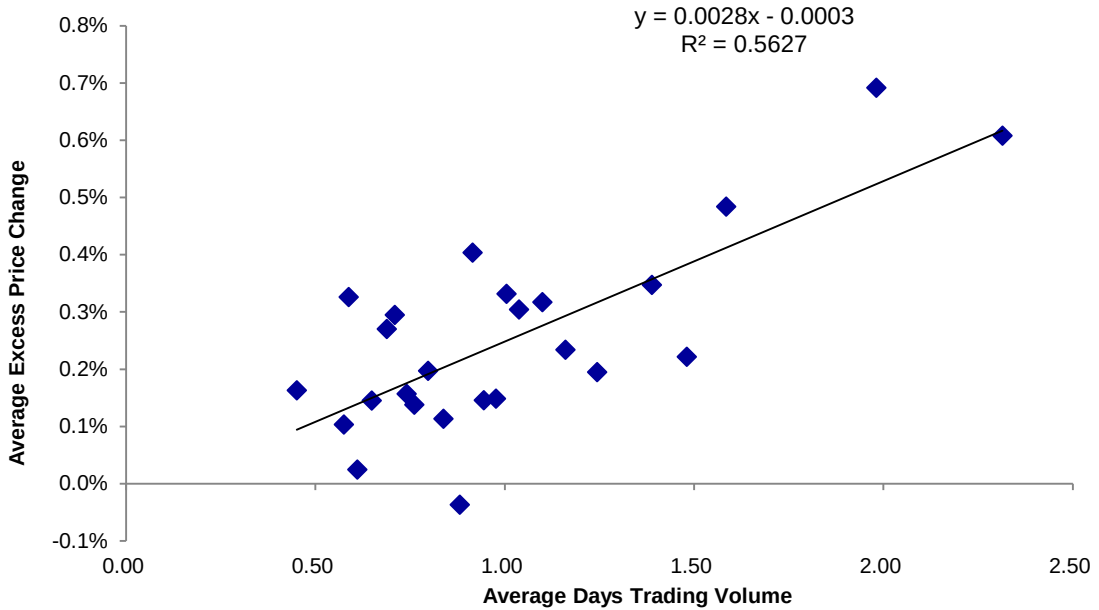
The Market Derived Blockage Discount Model

Selling period scenarios – 10 days



Price Change Group Summary

Price Change Group	Average Excess Price Change	Average Days Trading
1	0.6%	2.31
2	0.7%	1.98
3	0.5%	1.58
4	0.2%	1.48
5	0.3%	1.39
6	0.2%	1.24
7	0.2%	1.16
8	0.3%	1.10
9	0.3%	1.04
10	0.3%	1.00
11	0.1%	0.98
12	0.1%	0.94
13	0.4%	0.91
14	0.0%	0.88
15	0.1%	0.84
16	0.2%	0.80
17	0.1%	0.76
18	0.2%	0.74
19	0.3%	0.71
20	0.3%	0.69
21	0.1%	0.65
22	0.0%	0.61
23	0.3%	0.59
24	0.1%	0.57
25	0.2%	0.45

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SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.750149174
R Square	0.562723783
Adjusted R Square	0.543711774
Standard Error	0.00113197
Observations	25

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3.7926E-05	3.7926E-05	29.59833284	1.5749E-05
Residual	23	2.94712E-05	1.28136E-06		
Total	24	6.73972E-05			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	-0.000320167	0.000570609	-0.561097372	0.580157307	-0.001500562
X Variable 1	0.002802829	0.000515185	5.440434986	1.5749E-05	0.001737088

The Market Derived Blockage Discount Model

Determination of Adjusted Volatility	
Block Size	1,016,710
Excess shares ratio (DTV))	1.27
Avg Daily Volume (ADV)	371,866
Initial Implied volatility (IIV)	26.27%
Indicated Daily Price Decline (EC)	0.32%
Indicated number of shares traded	473,537
Excess Shares (indicated less average shares)	101,671
Indicated Dribble out Days	10.0
Weighted Average Dribble Out Days	5.0
Adjusted Volatility (AV)	31.4%

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Adjusted Volatility

Initial Volatility + Expected Daily Price Decline X SQRT (252)

.263 +(.32 X SQTR(252)) = .314, or, 31.4%

The Market Derived Blockage Discount Model

Put Option Analysis

	Variables		Inputs	Source
1	S	Asset Price	$68.35	Closing stock price on September 8, 2015
2	X	Exercise Price	$68.35	Closing stock price on September 8, 2015
3	T	Required Holding Period	0.02 years	Required holding period calculation
4	σ	Volatility Factor	31.4%	[b]
5	r	Risk-Free Rate of Return	0.02%	1-month U.S. Treasury rate; Federal Reserve Statistical Release
6	δ	Dividend Yield	0.0%	No distributions to be paid during dribble out period
7	**Calculated Value per Stock Option**		**$1.21**	[a]
8	Implied Discount		1.77%	

Notes:

[a] Based on the Black-Scholes put option formula as follows:

$P=(S*e^{-\delta T}N(d1)-X*e^{-rT}N(d2))-(S*e^{-\delta T})+X*e^{(-rT)}$

$d_1=[\ln(S/X)+(r-\delta+(\sigma^2)/2)T]/[\sigma\sqrt{(T)}]$

$d2=d1-\sigma\sqrt{(T)}$

[b] Based on the implied volatility of 26.3% (one-month put), adjusted upward to account for additional selling volume.

The Least Cost with the Highest Confidence

	5 Day	6 Day	7 Day	8 Day	9 Day	10 Day	11 Day	12 Day
Adjusted R2	26.68%	20.14%	34.97%	33.24%	28.06%	56.27%	42.64%	45.25%
Observations	50	41	35	31	27	25	22	20
Indicated Volatility	26.27%	26.27%	26.27%	26.27%	26.27%	26.27%	26.27%	26.27%
Adjusted Volatility	32.98%	32.33%	32.06%	31.82%	31.55%	31.42%	31.43%	31.30%
Put Price	$0.90	$0.96	$1.03	$1.09	$1.15	$1.21	$1.27	$1.32
Blockage Cost	$ 910,629	$ 977,756	$ 1,047,266	$ 1,111,161	$ 1,168,468	$ 1,226,838	$ 1,286,836	$ 1,338,520
Blockage Discount	**1.31%**	**1.41%**	**1.51%**	**1.60%**	**1.68%**	**1.77%**	**1.85%**	**1.93%**

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Direct Estimation of Equity Market Impact*

Robert Almgren,† Chee Thum,‡
Emmanuel Hauptmann,‡ and Hong Li‡

May 10, 2005§

Available at: http://www.cims.nyu.edu/~almgren/papers/costestim.pdf

Direct Estimation of Equity Market Impact

"The impact of large trades on market prices is a widely discussed but rarely measured phenomenon, of essential importance to sell and buy-side participants. We analyse a large data set from the Citigroup US equity trading desks, using a simple but realistic theoretical framework.

We fit the model across a wide range of stocks, determining the dependence of the coefficients on parameters such as volatility, average daily volume, and turnover."

Direct Estimation of Equity Market Impact

$$I = \gamma \sigma \frac{X}{V} \left(\frac{\Theta}{V} \right)^{1/4} + \langle \text{noise} \rangle$$

$$J = \frac{I}{2} + \text{sgn}(X) \, \eta \sigma \left| \frac{X}{VT} \right|^{3/5} + \langle \text{noise} \rangle$$

I = Permanent impact of order flow imbalance

J = Realized Impact

The Market Derived Blockage Discount Model

Direct Estimation Model Example 1 Day

			One Day
Estimated daily volume	V		1,000,000
Float	Θ		64,000,000
Inverse Turnover	Θ/V		64.00
Estimated Daily Volatility	σ		0.0370
Normalized Trade Size	X/V		0.8
Shares to be (sold) bought	X		(3,609,000)
Trade duration (days)	T		1.0
Permanent Impact Function	g(v)=γ	0.314	
Temporary Impact Function	h(v)=η	0.142	

Permanent Price Impact (I)	-12.35%
Temporary Impact (K)	-1.63%
Noise Component in I and J	-0.50%
Realized Cost (J)	**-7.81%**

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The Market Derived Blockage Discount Model

Blockage Discount
3,609,000 Shares of Acme Manufactiring, Inc.
Price impact of Various Selling Scenarios Using the Direct Estimation of Equity Market Impact

Selling Period (Days)	1	3	5	10	15
Shares Sold	3,609,000	1,203,000	721,800	360,900	240,600
Permanent Price Impact (I)	-12.35%	-5.81%	-3.15%	-1.70%	-1.29%
Temporary Impact (K)	-1.63%	-1.29%	-0.98%	-0.79%	-0.72%
Noise Component in I and J	-0.50%	-0.50%	-0.50%	-0.50%	-0.50%
Realized Cost (J)	**-7.81%**	**-4.19%**	**-2.56%**	**-1.63%**	**-1.37%**
Holding Cost	n.a.	-2.40%	-2.60%	-3.30%	-4.10%
Total Cost	n.a.	**-6.59%**	**-5.16%**	**-4.93%**	**-5.47%**

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Polling Question Number 6

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