РАЗДЕЛ 3
КОРПОРАТИВНОЕ
УПРАВЛЕНИЕ
В РАЗВИВАЮЩИХСЯ СТРАНАХ

SECTION 3
CORPORATE
GOVERNANCE IN
DEVELOPING COUNTRIES

HIGH VOLUME TRADES AND STOCK PRICE CHANGES IN BRAZIL

Andre Carvalhal*, Cesar Martins**, Otavio Figueiredo*

Abstract

This work analyzes the relation between stock price changes and high volume trades in Brazil. Using a unique intra-day database, we evaluate 10 of the most liquid shares from 2001 to 2006. Unlike most international studies, which are based on data from funds or institutional investors, this article breaks new ground by working with publicly available information. Our results indicate a positive and significant relation between stock price changes and high volume trades. In line with existing literature, we show there are both temporary and partially permanent on stock prices after high volume trades. Our study also indicates the existence of asymmetry between purchases and sales.

Keywords: Returns, Liquidity, Intra-Day Data

JEL: G12, G17

* *Pontifical Catholic University of Rio de Janeiro*
** *Federal University of Rio de Janeiro*

1. Introduction

In an efficient market, the value of an asset should reflect the exact present value of the expected cash flows created by this same asset with the information made available to all interested investors. When several small investors have access to the same information, price fluctuations should only occur with the disclosure of new information or with changes in the risk-return profile of the investors.

One can suppose that in a given market there are a large number of small investors, but also some investors that stand out due to their size. In such situation, it is possible to conceive that large investors may experience some difficulty in executing high volume orders since they may not find enough counetrparties for them. These orders may change the balance of prices with immediate and permanent consequences. The immediate effect is due to the instantaneous lack of market liquidity. The permanent impact happens through the tipping of the asset's demand curve, causing a real modification of its actual value.

Although extensively studied and accepted, these effects were very seldom measured for intra-daily operations due to the difficulty in obtaining data. With the increasing availability of data in electronic media, some studies have been done for developed countries (Chan and Lakonishok (1995), Chiyachantana, Jain, Jiang and Wood (2004), Almgrem, Thum, Hauptmann and Li (2005) and Bikker, Spierdijk and Van der Sluis (2007)).

The purpose of this paper is to analyze the impact of high volume operations over stock prices in Brazil. This paper innovates by working with publicly available information, as opposed to most international publications, which are based on proprietary data provided by funds or institutional investors and made available only to the authors of such papers. Although there are many international studies on the subject, intra-daily impacts of high volume orders have not yet been studied in Brazil. Using a database containing intra-daily data, 10 high liquid stocks are analyzed from 2001 to 2006.

The findings of this paper indicate a positive and statistically relevant relation between the impacts on stock prices and high volume operations. We show that there are temporary and permanent impacts on stock prices following high volume operations, and that these impacts are asymmetric for buys and sells.

The paper is structured as follows: the next section contains an overview of the literature review and Section 3 shows the data and methodology used in this work; Section 4 presents the results and Section 5 discusses the main conclusions of this study.

2. Literature Review

In the international literature one can find several studies analyzing, on an intra-daily basis, the impact of high volume operations on stock prices. Most of these works, it must be said, base their research on proprietary data provided by a given investor (investment funds, pension funds or other institutional investors).

Chan and Lakonishok (1995), Chiyachantana, Jain, Jiang and Wood (2004), Almgrem, Thum, Hauptmann and Li (2005) and Bikker, Spierdijk and Van der Sluis (2007) identify a positive relation between the volume of a given operation and its impact on stock prices. They also indicate the existence of an asymmetry in these results when comparing purchase and sale operations.

Even though most studies present similar findings, there is no consensus about the volume necessary for an operation to be considered a high volume one and able to cause some effect on stock prices. The first studies on the subject used as a parameter the proportion between the volume of the operation and the total volume negotiated on the same day. Almgrem, Thum, Hauptmann and Li (2005) have improved this method and use the ratio between the volume of the operation and a portion of the total daily volume negotiated in the same lapse of time in which the operation was executed.

Bikker, Spierdijk and Van der Sluis (2007) use two different and independent variables: the ratio between the volume of a single operation and the total volume of available stocks; and the ratio between the volume of this same operation and the total volume negotiated on the same day. Keim and Madhavan (1997) and Chiyachantana, Jain, Jiang and Wood (2004) show that the impact on stock prices is positively related to the complexity of the high volume operation, which is measured through the number of brokers involved and the number of days necessary for its execution.

Some authors analyze the relation between operation size and impact on stock prices in different countries. Bikker, Spierdijk and Van der Sluis (2007) demonstrate weaker impacts and lower transaction costs in the United States when compared to Europe, Japan and Canada. The authors explain that this difference may be related to the higher liquidity of the U.S. stock market.

Chiyachantana, Jain, Jiang and Wood (2004) study the impact of high volume operations in 39 countries and concude that they are more significant in emerging markets, which usually have worse corporate governance. The authors argue that good governance, a better enforcement of shareholders' rights and the existance of regulations against insider trading reduce the impact of the operations. Such finding corroborates the findings of La Porta et al. (1998), Bekaert and Harvey (2000), Domowitz et al. (2001), Jain (2001) and Bhattacharya and Daouk (2002), which indicate differences between transaction costs in many countries, which they relate to different kinds of governance.

The impact on stock prices is often defined in literature as the sum of temporary and permanent impacts. Kraus and Stoll (1972) define temporary impacts as those caused by a lack of immediate liquidity (price concessions aiming at stimulating buyers or sellers to give liquidity to a stock), inventory effects (temporary effects due to stock inventory imbalance) or imperfect substitution (price concessions to stimulate sellers or buyers to absorb additional shares).

The same authors define the permanent impact as a change in the way the market evaluates a given asset due to the information conveyed by the operation. In other words, a high volume buying operation may be an indication that a given stock is undervalued, leading to a reconsideration of its price by other market participants with a consequent permanent change in its price.

Even though different authors agree on these theoretical concepts, they use slightly different technical definitions. Bikker, Spierdijk and Van der Sluis (2007) define the temporary impact as the return of the stock between the time of the operation and a given moment after the operation; and the permanent impact as the return between a given moment immediately before the operation and a given moment after this same operation.

Other authors use different prices as benchmarks for similar definitions, arguing that, in many cases, prices immediately before or immediately after the operation are already (or still) under its influence. This is why it is not unusual to find studies that consider the closing price of the previous day or the opening price of the day of the operation as proxies for the price before the operation, and the closing price of the day of the operation or the opening price of the next day for the purpose of measuring permanent impact.

Chan and Lakonishok (1995) use as a measure of impact the difference between the price truly executed in the operation and the price of the asset at the opening of the first day of the operation. Keim and Madhavan (1997) and Chiyachantana, Jain, Jiang and Wood (2004) also consider the price truly executed during the trade.

To differentiate temporary from permanent impacts one must also measure the prices immediately after the operation and a sufficiently long time afterwards. Almgrem, Thum, Hauptmann and Li (2005) use the price immediately after the operation to measure temporary effect and the price 30 minutes later to calculate its permanent impact. Other authors use different lapses of time to measure permanent impact, such as 15 or 30 minutes, or even hours.

The analysis of the impact of high volume orders over prices must also consider that operations can be made in blocks. Barclay and Warner (1993), when studying the positioning of informed investors, conclude that when operating with small (up to 500 shares) or medium (500 to 10,000 shares) orders, the buyer (or seller) does not influence the market enough to justify the payment of a premium. For big orders (more than 10,000 shares), on the contrary, the market starts to notice the buying (or selling) operation and realizes that the investor has acces to some information not known to the market. Hence, the authors argue that the operation will be fragmented in several smaller operations in order to go unnoticed through the market, avoiding the payment of a premium.

The first studies on the subject (Kraus and Stoll (1972), Keim and Madhavan (1991) and Chan and Lakonishok (1993)) analyze the impact over prices of isolated trades and disregard the hypothesis of these operations being a part of a bigger "package". Chan and Lakonishok (1995) recognize that to institutional investors even positions considered to be average may represent a significant fraction of the total volume of some stocks. Therefore, it is perfectly natural that this investor breaks this operation in several smaller ones. And even these smaller operations may be broken down in minimal ones through computational algorithms. It would hence be wrong and useless to consider a single operation as the basic trade unit and to study the effects of these small operations on stock prices, since the trade as a whole would in this case be overlooked.

The authors then suggest the creation of a package of operations and observe price behavior around this package instead of around specific operations. Chan and Lakonishok (1995) find that the size of these packages has a significant influence on prices. The question then becomes how to define the package of trades. Chan and Lakonishok (1995) suggest the use of the investor's history to determine what is or is not part of the trade. As a general rule, they say that all the orders of a given investor should be aggregated until he stays out of the market for a considerable lapse of time.

Many authors indicate that there are significant differences on the impact caused by buying or selling operations (Kraus and Stoll (1972), Chan and Lakonishok (1993, 1995), Keim and Madhavan (1997) and Madhavan and Cheng (1997)). In general, purchase operations cause more impact than sales.

Chan and Lakonishok (1993) and Saar (2001) argue that purchase operations convey more information than sale operations. Since institutional investors usually do not carry an investment portfolio that is balanced according to the portfolio of the market, the option of selling does not necessarily convey bad information; the need to sell may be due only to a liquidity issue of this particular investor. On the other hand, the decision of buying a certain stock among all the others available in the market is more likely to convey positive information concerning a specific company.

3. Data and Methodology

3.1. Data

We use a database containing information on all intra-daily transactions occured in BM&FBovespa for 49 chosen assets from 2001 to 2006. From these 49 assets, the 10 with highest liquidity during this period are selected, since approximately 60% of the transactions and 80% of the volume operated are concentrated in the 10 most liquid companies.

The 10 companies analyzed are: Bradesco (bank), Braskem (petrochemical), Cemig (utilities), CSN (steel), Eletrobras (utilities), Gerdau (steel), Petrobras (oil and gas), Telemar (telecomunication), Usiminas (steel) and Vale (mining). The assets are selected in a way that most significant and competitive sectors in Brazil are represented, containing the most liquid firms for each category. The database contains the following information: date and time of the operation (on a second per second time scale), operation volume, trade price and the identification of the selling and buying brokers involved.

As previously mentioned, most of the previous studies were done "from the inside", meaning that they were done by researchers on the base of data supplied by investment funds or brokers. Thus, researchers knew beforehand when trades took place, their direction and whose intiative they were. In our study we are not in possession of the identity of the buyer or seller. Therefore, we make an approximation by using the broker as the buying or selling entity.

We know that in doing so we include a “noise” in a single operation, since all orders launched through a given broker, even if coming from different investors, will be considered as parts of a single package. However, since our analysis focuses on very high volume operations, way beyond the normal behavior of any broker for a given period of time, this noise should be small when compared to the size of the operations considered.

Another problem that arises is the possibility of a single investor spreading its orders through different brokers. Chiyachantana, Jain, Jiang and Wood (2004) study 39 countries (among them Brazil) and demonstrate that in average investors use between 1.10 and 1.31 brokers. They point out differences between trades executed in a single day (1.05 broker per investor) and in multiple days (2.02 brokers per investor). Since in the present work we analyze only orders executed in a single day, the supposition of the use of 1 broker per investor for the execution of the orders seems reasonable.

3.2. Methodology

Our methodology is based on Chriss and Almgrem (2003) and Almgrem, Thum, Hauptmann and Li (2005). It must be highlighted, however, that the present work differs from those done so far, since instead of using proprietary information we work with information that is publicly available. By doing so we add yet another difficulty to it, which is the identification of a high volume trade.

As seen in the previous section, there is no consensus around the value to be considered in order to qualify an operation as high volume. Almgrem, Thum, Hauptmann and Li (2005) find an average (median) volume of 1.51% (0.62%) of the total volume negotiated daily, and use as minimum cutoff values for high volume operations 0.25% of the total daily volume and at least 1,000 shares traded. Chan and Lakonishok (1995) find averages (medians) of 66% (11%) for buys and 61% (7%) for sales. Bikker, Spierdijk and Van der Sluis (2007) find an average volume for the operations of 4.3% of the total daily volume for buys and 3.4% for sales.

Hence, there is no single standard to define high volume operations. However, the use of some sort of cutoff value is necessary. Since we cannot precisely establish from which value operations become relevant, we adopt several cutoff values: 10%, 20%, 30%, 40% and 50%. We use 2 proxies to measure the volume of the operation: the ratio between the volume of the operation and the total volume negotiated during the same period; and the ratio between the volume of the operation and the total volume negotiated during that day.

The interval considered for the aggregation of the operations in packages is also an important factor on which there is no consensus in the literature. Bikker, Spierdijk and Van der Sluis (2007) show that operation packages usually last between 0.22h and 6.75h. Almgrem, Thum, Hauptmann and Li (2005) find average time for operation packages of 2.73h. In the present work, since our database is intra-daily, we consider different intervals (1 minute, 5 minutes, 10 minutes, 20 minutes and 30 minutes) to include an operation as part of a block.

Another difference between our study and most previous researches is that besides the immediate impact, we also measure the permanent impact of operations. In this regard, we have to estimate a lapse of time subsequent to the operation after which it no longer causes liquidity changes. Almgrem, Thum, Hauptmann and Li (2005) used a lapse of 30 minutes to measure the permanent impact, and we adopt this interval in this paper as well.

Most studies calculate the impact on stock returns adjusted for the market return. None of them, however, multiplies the market return by the stock beta, meaning that the authors simply calculate the return of the asset and subtract the return of the market. We use a simple modification of the model by the inclusion of the stock beta, as per equation 1 below:

$$\text{Stock Impact} = \text{Stock Return} - \text{Beta} \times \text{Market Return} \quad (1)$$

Barclay and Warner (1993), Chan and Lakonishok (1993), Chan and Lakonishok (1995), Chiyachantana, Jain, Jiang and Wood (2004) and Bikker, Spierdijk and Van der Sluis (2007) use only linear regressions to relate operation volume and price impact. Chriss and Almgrem (2003) and Almgrem, Thum, Hauptmann and Li (2005) alert, however, to the possibility of this relation being polynomial or exponential. The authors admit, nevertheless, that a very large amount of data would be necessary for a conclusion about the form of the equation to be reached. They assume, hence, that the polynomial form is the most likely one and use regressions to determine the parameters and coefficients. In our work, we test three functional formats: linear, polynomial and exponential.

Before presenting the results, we make an overview of the different proceedings followed. The first step is aggregating the operations according to their timing and to the broker or brokers involved. With the data aggregated per broker, we search for relevant operations by using different cutoff values (10%, 20%, 30%, 40% e 50%) according to the total volume negotiated in the period of the operation and to the volume negotiated during the day. This filter is not enough, since we may have high volume operations that are “confronted” by other high volume operations at the other end. Hence, besides being relevant, the operation has to be big enough to overcome this contrary pressure. In other words, we select, for instance, buys higher than 10% as long as at the other end there is no sale higher than 10%. Thus, we select only operations that we could clearly identify as a buy or a sale due to the dispersion of the operations at the other end through several brokers. Finally, we calculate the dependent variables: immediate impact (stock at the end of the operation minus the market return adjusted by beta) and permanent impact (stock return 30 minutes after the end of the operation minus the market return adjusted by beta).

We use two independent variables: volume of the operation/total volume negotiated during the same period, and volume of the operation/total volume negotiated during the same day. It is worth highlighting that the main explanatory variable is not merely the total volume of the operation, but its net volume. For example, having a buy of 80% of the volume and a sale of 40% of the volume, one may use as independent variable either the total negotiated volume (80%) or the net result of the operation (80% - 40% = 40%). We test both variables and the results are significantly stronger when the net volume is adopted instead of the total volume.

We estimate three equations to relate the dependent and independent variables:

$$Impact = \alpha_1 + \alpha_2 \times Volume \tag{II}$$

$$Impact = \alpha_1 + e^{\alpha_2 \times Volume} \tag{III}$$

$$Impact = \alpha_1 + \alpha_2 \times Volume^{\alpha_3} \tag{IV}$$

where *Impact* is the immediate and permanent stock return minus the market return adjusted by beta), *Volume* is the net volume of the operation (divided by the total volume negotiated during the same period and during the same day), α_1, α_2 and α_3 are estimated parameters. The coefficient that we are most interested in is α_2, which shows the relation between stock impact and operation volume.

4. Results

Six dimensions are analyzed: the type of impact (immediate and permanent), the cutoff value used in the selection of the operations, the time scale considered for aggregating the operations, the type of operation (buy or sell), the volume to be considered for the calculation of the net result (volume negotiated during the period of the operation or during the day) and the equation specification (linear, exponential, polynomial).

Due to the many dimensions analyzed, 36,000 regressions are estimated, being 3,600 per asset and 720 for each interval of each asset. From this total, 49% show a significant relation at the 5% level between impact on stock prices and operation volume. Table 1 shows the percentage of significant coefficients that relate stock impact and operation volume (α_2 in Eqs II to IV). One can notice that there are fewer significant values for bigger intervals. This seems consistent with the hypothesys according to which most of the impact is immediate.

Table 1. Percentage of Significant Coefficients that Relate Stock Impact and Operation Volume

This table shows the percentage of significant coefficients that relate stock impact and operation volume (α_2 in Eqs II to IV). Linear, exponential and polynomial regressions are estimated and the dependent variable is the impact on stock prices at the end of the operation or 30 minutes after the end of the operation. The models are estimated using different aggregation intervals (1, 5, 10, 20 and 30 minutes), and includes purchase and sale operations.

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale	Total
1m	63%	85%	49%	73%	71%	63%	65%	56%	81%	82%	69%
5m	57%	67%	39%	57%	58%	52%	56%	63%	64%	47%	56%
10m	45%	65%	38%	52%	59%	50%	49%	46%	52%	37%	49%
20m	25%	45%	32%	40%	53%	41%	37%	49%	34%	27%	38%
30m	31%	27%	26%	39%	43%	41%	28%	29%	28%	24%	32%
Total	44%	58%	37%	52%	57%	50%	47%	48%	52%	43%	49%

It is worth pointing out that the percentage of significant coefficients presented in Table 1 refers to all the estimated regressions and dimensions. Given that the number of analysis is enormous and due to lack of space we opt for presenting only the most relevant results here. However, all the results are available upon request.

We start modeling immediate stock impact through linear regressions. We use the cutoffs of 10%, 20%, 30%, 40% and 50% to define high volume operations. These cutoffs are applied to both the volume negotiated during the period of the operation and to the volume negotiated during the day. Table 2 shows the coefficients that relate stock impact and operation volume (α_2 in Eqs II to IV).

Most methods present a large number of significant coefficients, indicating that there is a relation between volume of the operation and impact on stock prices. The coefficients and their significance vary a lot according to the cutoff level, aggregation interval and company. However, we can note that the results are more significant for shorter intervals, which is in fact expected to happen. Therefore, for short intervals we are able to observe an almost immediate effect caused by the operation volume on stock prices. The 20% cutoff presents the largest number of significant coefficients.

Table 2. Impact on Stock Prices and Operation Volume for Different Cutoff Values

This table shows the coefficients that relate stock impact and operation volume (α_2 in Eqs II to IV). Linear regressions are estimated and the dependent variable is the impact on stock prices at the end of the operation. The models are estimated using different aggregation intervals (1, 5, 10, 20 and 30 minutes). Panels A to E show the results for the following cutoff values, respectively: 10%, 20%, 30%, 40% and 50%. These cutoffs are applied to both the volume negotiated during the period of the operation and to the volume negotiated during the day. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Panel A: 10% Cutoff

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	4.23**	7.37***	4.05*	4.85***	3.77***	2.84***	1.68***	1.75***	5.78***	2.25***
5m	5.29	2.67	5.69	4.94**	5.38***	2.00	3.21***	2.36***	5.77***	2.52**
10m	12.65	2.92	3.67	0.53	7.32***	6.56**	2.63	3.66**	8.52*	2.29
20m	4.37	0.86	13.23	10.68*	8.79**	14.62***	2.27	3.54	5.51	-1.43
30m	15.70	17.00*	6.61	3.78	10.48**	7.09	0.96	-5.23	6.33	-1.18

Panel B: 20% Cutoff

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	1.44**	4.09***	2.53***	1.80***	1.89***	2.15***	0.78***	0.57***	2.94***	1.34***
5m	2.29***	1.93**	2.74***	3.18***	2.08***	3.05***	0.90***	0.82***	1.66**	0.21
10m	1.90**	2.90***	2.13**	1.70*	2.94***	2.69***	0.72**	1.58***	1.08	1.76***
20m	2.02***	4.16***	2.12	2.30**	0.84	2.06**	1.66**	1.84**	2.09**	0.37
30m	3.78***	3.36	1.92	1.80	2.77**	3.09	0.93	1.67	1.85	0.40

Panel C: 30% Cutoff

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	1.33***	2.31***	1.48***	1.64***	1.57***	1.26***	0.51***	0.40***	1.33***	0.68*
5m	1.00	0.99**	1.10**	1.69***	1.03***	1.24***	0.61***	0.56***	1.40***	0.71*
10m	2.13	1.61	1.58**	1.49**	0.85	1.55***	0.69**	0.57**	1.51***	0.14
20m	2.51	1.71	0.03	1.48	1.83**	2.07**	0.84	0.93*	1.36	0.09
30m	-0.90	1.64	-0.35	0.80	2.47**	1.83	0.95	0.13	1.25	0.61

Panel D: 40% Cutoff

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	0.69***	0.98***	0.80***	0.91***	0.85***	0.72***	0.35***	0.32***	0.79***	0.44***
5m	0.19	1.31***	0.83***	2.02***	0.68***	0.79***	0.50***	0.69***	1.28***	0.28
10m	-0.54	1.37***	0.68	1.54***	1.04***	1.40***	0.49*	0.59**	1.60***	0.30
20m	-1.29	1.18	0.79	0.82	1.24*	1.40	1.22**	1.20**	0.59	0.87
30m	-2.73	0.60	0.10	2.11	1.30	2.82**	0.08	1.30	0.95	-0.24

Panel E: 50% Cutoff

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	0.48**	1.12***	0.65***	0.72***	0.75***	0.51***	0.31***	0.47***	0.66***	0.46***
5m	0.63	0.80***	0.77***	1.26***	0.41*	0.36	0.38***	0.65***	0.77***	(0.03)
10m	0.51	1.21**	0.32	0.59	0.91**	0.69	0.59**	0.16	1.32***	0.19
20m	4.59	1.39	1.34*	1.46	1.53**	0.55	-0.23	-0.32	1.38	-0.47
30m	-4.96	0.64	1.41	-0.11	0.63	1.33	-1.11	2.48**	2.12	0.43

As seen in Section 2, some authors use as independent variable the percentage of total volume during the lapse of time in which the operation is executed, while others use the percentage in relation to the volume negotiated during the day. Table 3 shows the results for both alternatives using a cutoff of 20% to define high volume operations.

Table 3. Impact on Stock Prices and Different Measures of Operation Volume

This table shows the coefficients that relate stock impact and operation volume (α_2 in Eqs II to IV). Linear regressions are estimated and the dependent variable is the impact on stock prices at the end of the operation. The models are estimated using different aggregation intervals (1, 5, 10, 20 and 30 minutes) and a cutoff value of 20%. Panels A and B show the results for different measures of operation volume: percentage of the volume negotiated during the day and percentage of the volume negotiated during the lapse of time in which the operation is executed. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Panel A: Percentage of the Volume Negotiated During the Day

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	1.55***	4.53***	3.43***	2.17***	2.48***	2.58***	0.92***	0.93***	3.04***	1.72***
5m	2.48***	4.20***	3.10***	2.94***	3.12***	2.58***	1.10***	0.92***	3.04***	1.54***
10m	2.55***	5.10***	3.81***	2.65***	3.62***	2.85***	0.86***	1.31***	2.86***	2.40***
20m	2.88***	5.99***	4.62***	3.06***	3.78***	4.28***	2.08***	1.94***	2.87***	3.17***
30m	4.63***	6.43***	4.49***	3.00***	3.76***	5.04***	1.32***	1.63***	4.53***	3.23***

Panel B: Percentage of the Volume Negotiated During the Lapse of Time in which the Operation is Executed

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	27.98***	41.82***	43.93***	50.61***	39.47***	52.01***	24.90***	19.89***	76.21***	49.03***
5m	16.17***	45.48***	33.74***	36.41***	46.02***	45.60***	28.28***	13.15***	70.69***	30.75***
10m	10.03**	43.60***	36.29***	39.43***	34.75***	42.71***	25.69***	12.52***	64.40***	26.45***
20m	6.87**	36.14***	33.67***	34.47***	34.95***	41.25***	19.04***	22.54***	57.23***	13.82***
30m	4.21**	42.86***	39.58***	24.08***	37.05***	51.92***	30.54***	10.45***	48.52***	21.12***

All coefficients that relate stock impact and operation volume (α_2 in Eqs II to IV) are significant at 1% or 5% levels. Therefore we can conclude that both alternatives to measure operation volume have a significant relationship with stock impact. The difference between both independent variables is minimal, indicating a slightly superior performance for the percentage volume negotiated during the day, which presents all coefficients significant at 1%. When the cutoff is modified (not only 20%), the percentage of the daily volume continue to present more significant coefficients than the percentage of the volume during the lapse of time in which the operation took place.

Table 4 brings a comparison between linear, exponential and polynomial models with a cutoff of 20% and using the percentage of the daily volume as independent variable. All coefficients that relate stock impact and operation volume (α_2 in Eqs II to IV) are significant at 1%. As can be seen, the results are similar for all models. When the analysis is repeated varying other dimensions, the linear model presents a slightly superior performance, with more significant coefficients than the other models.

Table 4. Linear, Exponential and Polynomial Relations between the Impact on Stock Prices and Operation Volume

This table shows the coefficients that relate stock impact and operation volume (α_2 in Eqs II to IV). Linear, exponential and polynomial regressions are estimated and the dependent variable is the impact on stock prices at the end of the operation. The models are estimated using different aggregation intervals (1, 5, 10, 20 and 30 minutes), a cutoff value of 20% and operation volume is measured by the percentage in relation to the total volume negotiated during the day. Panels A, B and C show the results of the linear, exponential and polynomial models, respectively. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Panel A: Linear Model

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	1.55***	4.53***	3.43***	2.17***	2.48***	2.58***	0.92***	0.93***	3.04***	1.72***
5m	2.48***	4.20***	3.10***	2.94***	3.12***	2.58***	1.10***	0.92***	3.04***	1.54***
10m	2.55***	5.10***	3.81***	2.65***	3.62***	2.85***	0.86***	1.31***	2.86***	2.40***
20m	2.88***	5.99***	4.62***	3.06***	3.78***	4.28***	2.08***	1.94***	2.87***	3.17***
30m	4.63***	6.43***	4.49***	3.00***	3.76***	5.04***	1.32***	1.63***	4.53***	3.23***

Panel B: Exponential Model

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	1.41***	0.63***	1.33***	1.77***	0.98***	1.40***	0.46***	2.76***	0.28***	0.53***
5m	1.76***	0.98***	7.62***	5.06***	0.96***	0.96***	1.77***	7.01***	1.46***	2.93***
10m	1.79***	1.24***	3.54***	1.66***	3.62***	2.75***	4.49***	2.41***	2.81***	2.13***
20m	7.99***	5.21***	13.62***	4.60***	6.85***	4.77***	1.26***	2.84***	5.13***	7.50***
30m	1.94***	2.86***	1.94***	6.20***	0.49***	3.08***	3.62***	5.53***	3.12***	2.66***

Panel C: Polynomial Model

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	1.47***	1.44***	1.96***	1.33***	1.33***	1.46***	0.76***	1.65***	0.64***	0.73***
5m	2.77***	1.41***	3.81***	2.83***	1.29***	1.10***	1.15***	2.84***	1.11***	1.74***
10m	7.43***	1.88***	3.07***	1.64***	2.78***	1.95***	1.52***	2.29***	1.60***	1.87***
20m	8.30***	4.09***	5.81***	2.81***	3.67***	3.45***	2.06***	2.04***	1.98***	5.71***
30m	43.40***	3.00***	2.51***	4.32***	1.27***	2.59***	1.62***	4.08***	2.40***	3.03***

We perform two additional analyses: buys vs. sales and impact on stock prices 30 minutes after the end of the trade. First we compare the results for buy and for sale operations to check if there is asymmetry between them. Table 5 presents the results for the linear models with a 20% cutoff and using the percentage of the daily volume as independent variable.

Table 5. Impact on Stock Prices and Operation Volume for Buying and Selling Orders

This table shows the coefficients that relate stock impact and operation volume (α_2 in Eqs II to IV). Linear regressions are estimated and the dependent variable is the impact on stock prices at the end of the operation. The models are estimated using different aggregation intervals (1, 5, 10, 20 and 30 minutes), a cutoff value of 20% and operation volume is measured by the percentage in relation to the total volume negotiated during the day. Panels A and B show the results of the model for purchase and sale operations, respectively.
***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Panel A: Purchase

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale	Average
1m	2.01***	6.08***	4.39***	1.76***	2.09***	2.10***	0.64***	1.21***	3.67***	2.35***	2.63***
5m	3.26***	5.25***	3.91***	3.13***	3.32***	2.52***	0.96***	0.70***	4.09***	1.73***	2.89***
10m	3.41***	6.38***	4.72***	2.70***	4.32***	3.17***	0.68***	1.63***	3.01***	3.31***	3.33***
20m	4.15***	8.13***	6.89***	2.37***	3.62***	6.77***	2.68***	2.06***	1.43***	4.66***	4.27***
30m	6.85***	10.17***	6.49***	2.57***	3.27***	6.85***	0.73***	1.07***	4.87***	3.71***	4.66***

Panel B: Sale

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale	Average
1m	1.07***	2.92***	2.43***	2.60***	2.89***	3.08***	1.21***	0.64***	2.38***	1.06***	2.09***
5m	1.67***	3.11***	2.26***	2.74***	2.91***	2.64***	1.25***	1.15***	1.95***	1.34***	2.10***
10m	1.65***	3.77***	2.86***	2.60***	2.89***	2.52***	1.05***	0.98***	2.70***	1.45***	2.35***
20m	1.56***	3.76***	2.26***	3.78***	3.95***	1.69***	1.46***	1.82***	4.37***	1.62***	2.73***
30m	2.32***	2.54***	2.41***	3.45***	4.27***	3.16***	1.93***	2.21***	4.18***	2.73***	2.92***

All coefficients that relate stock impact and operation volume (α_2 in Eqs II to IV) are significant at 1% for both buys and sales. Consistent with existing literature, there is a difference between the impact caused by purcahse and sale operations. The values for the purchase coefficients are significantly higher than those of the sale operations.

Finally, instead of analyzing only the immediate stock impact after the operation, we also investigate the impact 30 minutes after the end of its execution. Based on previous studies, our expectation is to find weaker results if compared to those of the immediate impact. Table 6 presents the results for immediate and permanent stock impacts.

Table 6. Immediate and Permanent Impact on Stock Prices and Impact 30 Minutes After the End of the Operation and Operation Volume

This table shows the coefficients that relate stock impact and operation volume (α_2 in Eqs II to IV). Linear regressions are estimated and the dependent variable is the impact on stock prices at the end of the operation and 30 minutes after the end of the operation. The models are estimated using different aggregation intervals (1, 5, 10, 20 and 30 minutes), a cutoff value of 20% and operation volume is measured by the percentage in relation to the total volume negotiated during the day. Panels A and B show the results for the immediate and permanent impacts, respectively. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Pannel A: Impact Imediately after the End of the Operation

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	1.55***	4.53***	3.43***	2.17***	2.48***	2.58***	0.92***	0.93***	3.04***	1.72***
5m	2.48***	4.20***	3.10***	2.94***	3.12***	2.58***	1.10***	0.92***	3.04***	1.54***
10m	2.55***	5.10***	3.81***	2.65***	3.62***	2.85***	0.86***	1.31***	2.86***	2.40***
20m	2.88***	5.99***	4.62***	3.06***	3.78***	4.28***	2.08***	1.94***	2.87***	3.17***
30m	4.63***	6.43***	4.49***	3.00***	3.76***	5.04***	1.32***	1.63***	4.53***	3.23***

Pannel B: Impact 30 Minutes after the End of the Operation

Stock / Interval	Bradesco	Braskem	Cemig	CSN	Eletrobras	Gerdau	Petrobras	Telemar	Usiminas	Vale
1m	0.93	5.47***	3.76***	1.75**	3.80***	2.62***	0.73***	0.16	2.04***	1.66***
5m	1.76*	3.17***	3.57***	3.60***	2.54***	2.58***	1.00***	0.89***	2.27***	1.90***
10m	0.53	6.72***	2.89***	2.35***	3.70***	1.62***	0.93***	1.32***	1.35***	2.23***
20m	5.15***	6.62***	5.05***	3.05***	4.25***	3.93***	2.54***	2.13***	3.62***	3.92***
30m	5.08**	7.59***	4.40***	2.46**	3.28***	4.92***	1.33**	1.63***	4.73***	3.12***

By observing the number of significant coefficients it is possible to notice that the significance of the results for permanent impact is slightly lower than that of the immediate impact. However, the permanent impact continues to be significant in most cases. This result led us to also test the the permanent impact in longer periods (60 and 120 minutes after the execution of the operation). The results (not reported here) indicate that the significance falls substantially, practicaly eliminating the existence of significant coefficients.

5. Conclusion

There are numerous studies in international literature that analyze, on an intra-daily basis, the impact on stock prices decurring from high volume operations. In general, these are researches based on proprietary data provided by some investors and reveal in their findings the existence of a positive relation between the size of the operation and its impact on stock prices.

This paper analyzes the impact on stock prices of high volume operations executed in Brazil. It is groundbreaking work in the sense that it is based on publicly available data, with intra-daily information on 10 high liquidity stocks, from 2001 to 2006. In this regard, this paper differs from most studies found in the international literature.

Confirming previous observations, we have found that there are significant changes in stock prices after a high volume operation, be it a purcahse or a sale. Our results confirm the existence of temporary and partially permanent effects and of an asymmetry in the impacts caused by purchases and sales.

References

1. Almgren, R. (2003). Optimal execution with nonlinear impact functions and trading-enhanced risk, *Applied Mathematical Finance*, 10, 1–18.
2. Almgren, R., Thum, C, Hauptmann, E & Li, H. (2005). Equity market impact, *Journal of Risk*, 18, 57–62.
3. Almgren, R. & Chriss, N. (2000). Optimal execution of portfolio transactions, *Journal of Risk*, 3, 5–39.
4. Barclay, M. & Warner, J. (1993). Stealth trading and volatility: which trades move prices?, *Journal of Financial Economics*, 34, 281-305.
5. Bhattacharya, U. & Daouk, H (2002). The world price of insider trading, *Journal of Finance*, 57, 75-108.
6. Bikker, J., Spierdijk, L. & Van der Sluis, P. (2007). Market impact costs of institutional equity trades, *Journal of International Money and Finance*, 26, 974-1000.
7. Blume, M., MacKinlay, C & Terker, B. (1989). Order imbalances and stock price movements on October 19 and 20 1987, *Journal of Finance*, 44, 827-848.
8. Chan, L. & Lakonishok, J. (1993). Institutional trades and intraday stock price behavior, *Journal of Financial Economics*, 33, 173-199.
9. Chan, L. & Lakonishok, J. (1995). The behavior of stock prices around institutional trades, *Journal of Finance*, 50, 1147-1174.
10. Chiyachantana, C., Jain, P., Jiang, C. & Wood, R. (2004). International evidence on institutional trading

behavior and price impact, *Journal of Finance*, 59, 869-898.
11. Domowitz, I., Glen, J. & Madhaven, A. (2001). Liquidity, volatility, and equity trading costs across countries and over time, *International Finance*, 4, 221–255.
12. Finucane, T. (2000). A direct test of methods for inferring trade direction from intra-day data, *Journal of Financial and Quantitative Analysis*, 35, 553-576.
13. Hasbrouck, J. (1988). Trades, quotes, inventories, and information, *Journal of Financial Economics*, 22, 229-252.
14. Hasbrouck, J. (1991). Measuring the information content of stock trades, *Journal of Finance*, 46, 179-207.
15. Holthausen, R., Leftwich, R. & Mayers, D. (1987). The effect of large block transactions on security prices: a cross-sectional analysis, *Journal of Financial Economics*, 19, 237-267.
16. Jain, N. (2001). Monitoring costs and trade credit, *Quarterly Review of Economics and Finance*, 41, 89-110.
17. Keim, D. & Madhavan, A. (1997). Transaction costs and style: an inter-exchange analysis of institutional equity trades, *Journal of Financial Economics*, 46, 265–292.
18. Kraus, A. & Stoll, H. (1972). Price impacts of block trading on the New York stock exchange, *Journal of Finance*, 27, 569-588.
19. Lee, C. & Ready, M. (1991). Inferring trade direction from intraday data, *Journal of Finance*, 46, 733-746.
20. Madhavan, A. & Cheng, M. (1997). In search of liquidity: block trades in the upstairs and downstairs markets, *Review of Financial Studies*, 10, 175-203.
21. Saar, G. (2001). Price impact asymmetry of block trades: an institutional trading explanation, *Review of Financial Studies*, 14, 1153-118.
22. Spierdijk, L., Nijman, E. & Van Soest, A. (2002). The price impact of trades in illiquid stocks in periods of high and low market activity, *Tilburg University Discussion Paper*, 29.