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The magic of certain numbers:
Stock price clustering -- developed markets vs. emerging markets

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Abstract

This thesis gives insight into the differences between emerging and developed stock markets on the phenomenon of price clustering. A country comparison is made, based on the level of development of the relevant stock markets (developed vs. emerging). Stock Exchanges considered are the Australian Stock Exchange, the NYSE and the Dutch Stock Market, which are all developed Stock Markets; and the Bolsa Mexicana de Valores, the Shanghai and Shenzhen Stock Exchange in China and the Singapore Stock Exchange (SES), which are the emerging markets. Results show clear differences, and various reasons pushing behind the different results are discussed.

Keywords:

Price clustering; Emerging markets; Developed markets; Country comparison; Behavioral economics.

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Chapter 1: Introduction

Magic seems to happen in a lot of financial markets, and it is remarkably persistent through time. When looking at equity (bid, offer and trade prices) markets, IPO prices, takeover bids and rights issues and even in the forex and gold markets, a phenomenon called price clustering occurs. It means that prices cluster on (mainly) round fractions. It's possible to say that they cluster on "beautiful" numbers. In addition to integers, it's also possible for prices to cluster on halves, odd quarters and odd eights. The frequency with which prices cluster overall also decreases in that order mentioned. This phenomenon is related to human behavior, as a lot of psychological experiments have proven that clustering of outcomes around round numbers is a fundamental attribute of this behavior. Osborne and Niederhoffer were the first to touch this subject of price clustering in the 1960s. Osborne wanted to shed light on some of the internal properties of prices and found through statistical tests that some common beliefs about the market are backed up by evidence, while the data from other natural phenomena tended to be a problem for analysis. Niederhoffer observed price clustering in the closing prices of actively and inactively traded shares, high- and low-priced shares and in noon and in closing prices. Important to state is that he expected price clustering to occur more frequently on public auction markets than on dealer markets. Harris found in 1991 that the phenomenon was still present and that clustering varies across exchange types.

The reasons behind this phenomenon are diverse and extensive. Various ideas and hypotheses are stated behind this phenomenon. In short, Niederhoffer said that it was because public limit orders are placed consciously at round numbers. Because of that the idea is that clustering should occur more frequently on public auction markets than dealer markets. For Ball et al. the thought was that

it is the extent to which the underlying value of a security was known that was at the basis of the phenomenon.

It is standard for financial economists to assume that agents operating on the stock markets are rational and that these markets are efficient. When this is the case, traders are not suppose to have preferences for prices that end in specific digits, which means that on an efficient market prices should be uniformly distributed over time. Thus price clustering can in turn be used to predict prices. This is a sign that the market is operating inefficiently, because these predictions should not be possible. In other words, this price clustering phenomenon is in contradiction with the random walk theory we've all become so familiar with (Narayan, Narayan, Popp, & D'Rosario, 2011).The market efficiency problem is the main reason for investigating this not yet very popular phenomenon of price clustering in the share price market.

When looking at price clustering, it seems to occur in a different way on emerging stock markets compared to the more developed country's stock markets. In addition to that, emerging markets also differ from each other on the basis of cultural factors, terrorism and sporting events that occur in the countries in which the Stock Markets are based. When talking about cultural factors, we talk about beliefs and superstitious ideas that are characteristic for every country in a different way. When talking about economic factors, we talk about inflation, interest rates etc. All of these stated above impact the movements on the stock markets in numerous ways. That is why it is the aim of this thesis to research how emerging markets differ from developed markets, and why.

 A comparison of the Stock Exchanges in three developed countries (USA, Australia, The Netherlands) and three developing countries (Mexico, China, Singapore) showed that there is indeed a difference in the way the

phenomenon presents itself on the Stock Markets. The potential reasons why are also diverse.

The more developed stock markets provide a baseline for interpreting price clustering. The data for these markets showed that the frequency at which prices cluster is relatively high. For example, on the NYSE about 15% to 30% of the total trades of stock prices between 10 and 100 currency units were performed on integers. In addition to that finding, developed stock markets tend to move in sync with various theories and hypotheses developed about price clustering. For example, the hypothesis by Harris that states that price clustering increases with own price level. The data (and figure) for the Australian Stock Exchange, provided evidence that this is in fact true. The other developed stock markets also provided evidence for this theory.

The frequency at which the prices clustered on the Shenzhen and Shanghai Stock Exchange was notably lower than on the NYSE. More specifically, only 3% to 6% of the total trades of stock prices between 20 and 40 currency units were performed on round integers.

On the Bolsa Mexicana de Valores, a notable difference was the fact that some of the data of this stock market contradicted hypotheses and ideas. The most remarkable finding was that, inconsistent with theory, the companies' own share price had a negative effect on price clustering. Usually the opposite is observed, thus proving that there are other influences on the different stock markets. The idea behind this could be that agents on this stock market are more concerned with the finer partitions of price, thus prompting a different outcome. Also, the fact that Mexico has been victim of several devaluations makes for quite an uncertainty of the underlying value for the agents on this stock market. This in turn also influences how agents act.

In line with the other developed markets, the Singapore Stock Exchange (SES) behaved quite in sync with the basic theories about price clustering. Although this stock market is pretty consistent with theory, it did show one notable difference which is the fact that prices ending in twenty-five and seventy-five cents were not observed. The fact that the SES did not overall deviate from developed Stock Markets' movements might be because despite being labeled an emerging market, it is a highly developed market its category, "the emerging group". As Singapore did not deviate a lot from the developed stock markets' movements, it could be suggested that as a Stock Market moves towards more development, it starts moving more in line with the ideas that are hypothesized about price clustering.

Chapter 2 of this thesis ventures into the world of price clustering. It starts by specifying what price clustering is and what the (potential) reasons behind it are. Various ideas and hypotheses by the major contributors to this topic are discussed. This is just to give a basis of price clustering on which the rest of the thesis will further build. Chapter 3 continues with the analysis of price clustering on developed and emerging stock markets. The background information on the six countries is elaborated. Afterwards, a comparison is made based on the differences in outcomes of price clustering between the countries. Later the latter is discussed. Chapter 4 gives a brief summary of the thesis and concludes.

Chapter 2: Literature Review

2.1 What is price clustering?

A simple definition of price clustering is "the phenomenon that some prices are more frequently observed than others". A common observation is that stock prices tend to end in decimal points that are "round numbers", for example the numbers 5 and 10. This is in contradiction with the random walk predictions most people know and expect. The random walk theory is an event that occurs and is determined by a set of random movements. In other words, it is not possible to predict the event beforehand. When this theory is applied to stock markets, it suggests that stock prices adjust at random thus making it impossible to predict them. The idea behind the random walk theory is that markets are operating efficient and thus cannot be beat by predicting the exact movements of the market (Phung, 2008).

Osborne was the first to start the research into the phenomenon of price clustering in 1962.He wanted to investigate a few internal properties of common stock prices in detail and wanted to see more precisely how general properties of the well known Brownian motion arise. The Brownian motion refers to the mathematical problem that describes random movements of stock prices. Osborne found that the fact that this motion exists does not mean that there is no underlying rational structure. Some underlying structure was found to be associated with what they called "unrelieved bedlam", which is wizardry/magic, so to speak. In short, the Research by Osborne tried to show that some common beliefs about the market are answered for by evidence through statistical tests, while there are natural phenomena whose data present problems for analysis (Osborne, 1962).

Osborne was followed by Niederhoffer in 1965 and 1966. Niederhoffer had the idea that price clustering occurs because public limit orders are presented at

round prices, which means that clustering should be more frequent in public auction exchange markets than in dealer markets. Limit orders are not submitted in dealer markets, but are in public auction exchange markets. To give a short explanation on how orders to buy and sell on the Exchange work, Niederhoffer explains three categories, namely market, limit and stop. A market order dictates the broker to buy or sell at the best price available when the order reaches the floor. Buy-limit orders instruct the broker to obtain the stock at the limit or below the limit and sell-limit orders instruct the broker to offer the stock at a specific price or higher. And last but not least, a stop order will become a market order at the first moment it hits the floor. Niederhoffer stated that since market orders are mostly placed via phone at a speaker's leisure and stop orders are only a small part of total trading, it is logical to look at limit orders when researching the price clustering phenomenon (Niederhoffer, 1964).

Niederhoffer found this clustering in the closing prices of actively and inactively traded shares, high- and low-priced shares and in noon and in closing prices. He claimed that market participants feel "safe" placing their orders at numbers that they are accustomed to deal with, which results in this price clustering at whole and round numbers (Aitken, Brown, Buckland, Izan, & Walter, 1996).

In 1991, Harris found that years after the researches by Niederhoffer and Osborne that the price clustering phenomenon was still very present at the NYSE. Harris hypothesized that price clustering increases with price level and volatility. Furthermore, it decreases with capitalization (which is a measurement of corporate or economic size of a public company) and transaction frequency. Capitalization is equal to the company's share price multiplied by the number of outstanding shares. Harris' idea behind price clustering was that it occurs because traders use a discrete set of prices when negotiating to simplify these negotiations.

Because of exchange regulations, it is usual for stocks to be traded on eights, which means that the smallest possible spread is 12,5 cents. This idea is derived from the method of counting on the hands, similar to the decimal system and was later called "pieces of eight". The spread is the smallest amount that a stock can change in value. This might seem insignificant, but is crucial when trading thousands and sometimes even millions of shares of stock, because it could amount to a large sum in the end. Fractions smaller than eights are rarely used, however fractions of sixteenths (6,25 cents) were later added to the stock exchanges. (Why does the stock market use fractions?, 2008). Larger fractions than eights can be explained by traders choosing to restrict further their terms of trade to the sets of quarters, halves and whole numbers. It may be customary or the result of explicit agreements among traders. An econometric model prompted results to project the fact that traders frequently used odd sixteenths if permitted, when trading low-price stocks.

Important to state in short is that, Harris found that integers are more common than halves, halves are more common than odd quarters and odd quarters are more common than odd eights. Other fractions were almost never observed. Throughout his article, he assumed that the discrete price sets are used to lower negotiating costs. For example, one can look at home prices which are almost always negotiated on 1000s and 5000s, though there is no legal rule for this. A smaller set of prices restricts the number of different offers and bids that can be made. Negotiations can then b e wrapped up faster since skittish offers and couteroffers are limited. Also, a smaller set of prices restricts the amount of information that has to be exchanged between traders when negotiating which decreases the time that is needed to strike a bargain (Harris, 1991).

2.2 Reasons behind price clustering

As mentioned above, there are various reasons and ideas behind the phenomenon called price clustering. This part of the paper will give a brief overview of these underlying issues and explain them a bit further.

First we saw the idea by Niederhoffer that clustering occurs because public limit orders are presented at round numbers. In other words, it is to be expected that price clustering should appear more frequently in public auction exchange markets than in dealer markets.

Harris' idea was that clustering occurs because negotiators use a discrete set of prices when negotiating to simplify this process. He came up with the following relations. According to Harris, price clustering increases with price level and volatility and decreases with capitalization and transaction frequency. Traders use this discrete set of prices to simplify their negotiations, because a smaller set of prices limits the amount of bids and offers that can be made. It also makes for less information that has to be exchanged between the negotiating traders. The result is that negotiations can be closed faster due to a restriction of insignificant offers and reduced negotiation time (Harris, 1991).

Stock price level is the price of saleable stock of a company, represented by the present value of future cash flows. The stock of a company contains numerous shares, which means that on individual level they are called "share price". Volatility measures the variation of the price over time; as such a lot of fluctuations represent an unstable and uncertain price, which accounts for uncertainty. Uncertainty is a big prompter for price clustering. A bigger firm and higher transaction frequency might serve as a sign of more experience and thus certainty. Because of that the expected relation with clustering is negative.

Figure 1, which represents price clustering on the Australian market shows that clustering increases with price level, as the relative frequency of final digit prices of for example 0 and 5 increases with the price level (in cents).
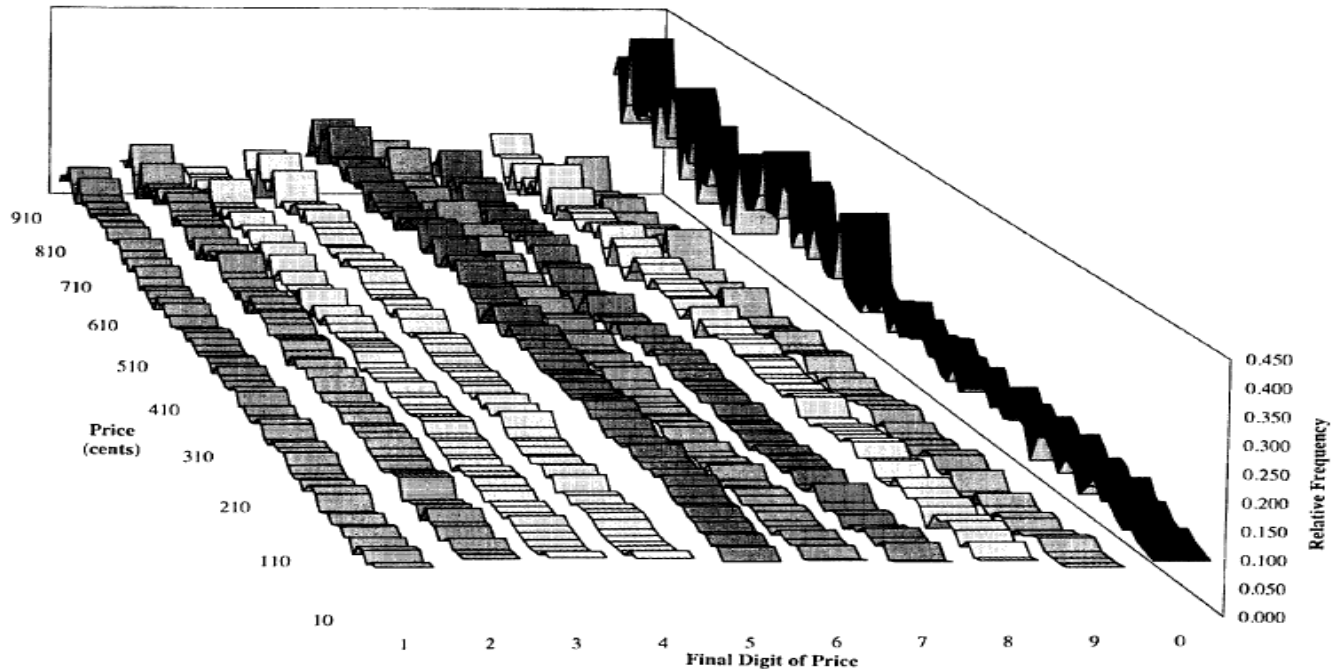

Fig. 1. Relative frequency of final digit of all SEATS trade prices with a tick size of one cent.

Figure 1: taken from "Price clustering on the Australian Stock exchange" by Michael Aitken, Philip Brown, Christine Buckland, H.Y. Izan, Terry Walter, (1996).

Ball et al. introduced the "price resolution hypothesis", which states that the extent to which prices cluster (in their study specified on the gold market) depends on how well known the underlying value of a security is. If this value is not well known, prices will cluster more extensive. The motivation behind this hypothesis is also the fact that negotiators use discrete price sets to lower costs. Furthermore, the size of the price set (and in turn the extent of price clustering) depends on the balance between gains lost from trades and lower negotiating costs. If traders use a small price set during negotiations the costs may be low.

However, gains-from-trade may be lost either way if this set does not include a price that is accepted by both parties. These lost gain-from-trades are more probable when for example underlying security values are well known, as this means that little spreading exists among the trader reservation prices. The article by Ball et al. provides more understanding into the determination of prices in a competitive market. They found that the rate of price resolution depends on the sum of information in the market, the level of the price and the variation of the price (Ball, Walter, & Adrian, 1985).

The market microstructure theory states that price clustering occurs because traders are constantly trying to determine the true price of an asset, which is called the price discovery process. Ball et al. (1985) and Harris and Godek in 1996 hypothesize various ideas about this (Godek, 1996).

In short, Ball et al. state that the degree of true price uncertainty is positively related to clustering, conditioned on the rules of and regulations of the trading activity. They looked at the London gold market and saw that this phenomenon is important from the point of view of the microeconomics of price formation (Ball, Walter, & Adrian, 1985). Harris and Godek state that true price uncertainty should be modeled using economic fundamentals, such as price level, price change volatility, trading activity and firm size, as instrumental variables. These show that clustering increases with volatility and price level, and decreases with firm size and transaction frequency. Another way to view price clustering is as means to lower negotiation costs (He & Wu, 2006).

Various studies into this phenomenon have been conducted and are still being conducted. Many reasons for this price clustering were observed. However, a lot of studies seem to contradict each other in their results, which is an interesting fact to consider. It seems that one of the reasons behind this contradiction is the difference between stock markets in developed countries and developing

countries, which make for different outcomes of the price clustering phenomenon.

2.3 Emerging versus developed markets

Morck et al. (2000) found that stock prices move together more in poor economies than in rich economies. This is not a result of market size nor is it completely accounted for by higher fundamentals correlation in low-income economies. Measures of property rights, however, seem to explain the difference. In emerging markets, the systematic component of returns variation is large. In more developed markets higher firm-specific returns variation is linked to stronger public investor property rights. Morck. Et al thus suspected that property rights foster informed arbitrage and capitalizes detailed firm specific information (Roll, 1992).

Roll said in 1988 that the relative amount of firm-level and market-level capitalized into stock prices explains the extent to which stock prices move together. Morck et al. noticed that stock prices in countries with a high Gross Domestic Product tend to move fairly unsynchronized while stock prices in low GDP countries have a tendency to move up or downward together (Morck, Yeung, & Yu, 2000).

Morck et al. deliberated three explanations that could possibly be behind this. First of all, firms in countries with a low GDP might have more correlated fundamentals. An example is that these economies tend to be undiversified. Second, low-income countries tend to provide a poor and uncertain safeguard of private property rights. For example, political events and just plain and simple rumors can already cause stock price swings in such countries. Last but not least, countries that offer poor protection of private property rights might prompt problems such as intercorporate income shifting that make firm-specific

information less useful and interesting to risk arbitrageurs. The whole idea of capitalization of firm-specific information into stock prices is then obstructed.

In short, it could be explained by saying that emerging markets are less skilled in processing information, whereas stock markets in more advanced countries are. And the latter happens to be a distinctive feature of an efficient market.

Chapter 3: Price Clustering: Developed vs. Emerging Markets

3.1 The six countries

In order to study the difference between developed and emerging markets, it is logical to compare a few developed markets against emerging markets. Levine et al. examined various variables to measure the development of a stock market in 1994. They examined data on forty-four emerging and developed markets between 1986 and 1993 and used indicators such as stock market size, market liquidity, market concentration, market volatility, integration with world capital markets and institutional development. As these measures will not capture all the aspects of a stock market individually, the goal of Levine et al. was to yield a set of stylized facts about the different indicators of stock market development to facilitate and stimulate research. They found that the three most developed markets in the world are The United States, The United Kingdom and Japan (Demirguc-Kunt & Levine, 1994).

 Harris, who is mentioned the most throughout this article investigated the well-known NYSE, which is why it's the first market chosen to be used as a developed market. Furthermore, markets such as The Netherlands, France, Canada, Sweden, Norway and Australia are considered developed markets as richer countries overall have more developed stock markets (Demirguc-Kunt & Levine, 1994).

Emerging stock markets make for a disproportionate share of the booming growth of the World Stock Markets. The first article I read about the phenomenon called Stock Price Clustering was the article by He and Wu on China's Shenzhen and Shanghai Stock Market. This market is considered to be an emerging market, which is why the first country chosen for the analysis is China. As only a handful of studies have been done based on South America, I thought it fit to include Mexico in the analysis. And last but not least, as

Singapore is one of the most popular emerging markets, it was logical to also consider this country in the analysis.

In the following section each country is shortly discussed.

3.1.1 Australia, developed market

Aitken et al. (1996) did an investigation into price clustering on the Australian Stock Exchange by looking at the individual trades effected on this market. The Australian Stock Exchange is a wholly computerized, order-driven trading system and is considered a rather developed Stock Exchange market. Brokers are the principal agents for their clients. When the market opens, an auction is held which thereafter should result in a market order meeting the price of the best opposing limit order. This is how the price at which a trade will be executed on the ASX is recorded.

Most of the data used for their analysis was obtained from the full set of SEATS transactions on the ASX. From this database they formed another database delimited on the basis of ordinary fully paid shares that traded at least five times per day on average, in the period from September 3rd 1990 up to and including September 3rd 1993. The only trades that Aitken et al. considered were the regular ones transacted in the six hours of "Normal Trading Mode".

Their main findings were, as expected for a developed market, that price level (which Aitken et al. consider to be a sign of imprecision in beliefs about firm value), market volatility, own stock volatility , trade size and the size of the bid-ask spread (which are surrogates for greater haziness) all increased clustering. Price clustering decreased when the trade frequency went up and was lower for stocks with options traded on them (Aitken, Brown, Buckland, Izan, & Walter, 1996).

3.1.2 New York, developed market

Harris looked into another developed Stock Market, which is the well known NYSE. He stated that most stocks should be traded on eights. As said before, he found that clustering increases with price level and volatility, and decreases with firm size and transaction frequency, which is consistent with the findings on the Australian Stock Exchange previously discussed. Notice the similarities between the two developed Stock Markets. Harris was also the one who found that this phenomenon is persistent through times and across exchange markets.

He used an econometric model estimate of stock price clustering, which assumed that agents on the Stock Markets use discrete price sets that are based on larger fractions than the accustomed 1/8 dollar minimum price variation. Results showed that traders would repeatedly use odd sixteenths, if permitted, to trade low-price stocks (Harris, 1991).

Chung and Ness also looked into the NYSE. Specifically, they examined execution costs and quote clustering on the NYSE, but also on the NASDAQ. In other words they did a comparison. They used 517 pairs of stocks that matched after decimalization and found that on the NYSE the mean spread was notably smaller than on the NASDAQ when weighting the spreads equally across stocks. In addition to that the difference between the two exchanges is larger for small stocks. When spreads are volume weighted, the mean is notably narrower for NASDAQ than for NYSE. The difference is significant for larger stocks. They also found that high degrees of quote clustering was present on the NYSE. This occurred on nickels and dimes.

Interesting to state is that Chung and Ness found, in line with numerous other studies that execution costs on the NASDAQ were significantly higher than on the NYSE. The thought behind this is that because of the confirmative obligations of NYSE specialists to maintain reasonable spreads in their specialties execution

costs can be maintained low for small and low-volume stocks. In addition to that they found that stocks with a higher degree of quote clustering also have wider spreads. Notice that a wider spread goes hand in hand with higher execution costs. This can then in turn be linked to Harris' idea that price clustering moves in sync with the level of negotiation costs (Chung, Van Ness, & Van Ness, 2004).

3.1.3 The Netherlands, developed market

Joep Sonnemans tested two rival hypotheses by looking at Data from the Dutch Stock Market between 1990 and 2001. The Dutch Stock Exchange belongs to the well developed European market. After January 1st 1999 stock prices were listed in euros, whereas guilders were still the daily life currency until 2002.

This allowed him to test what changed after switching from Guilder notation to Euro notation on the Stock Market. The first hypothesis is the aspiration level hypothesis that predicted that round number effects in guilders would only slowly disappear. Secondly, the odd price hypothesis predicted an abrupt change in round number effects after January 1st 1999. The data was split in two parts, namely from 1990-1998 and 1999-2001, which are respectively the guilder and euro time frames. The daily unadjusted closing prices were acquired to study the phenomenon. A small computer program was used to compute price barriers by counting the crossings.

Sonnemans found that indeed price clustering happens on the Dutch Stock Market. To be more specific, in the guilder years whole numbers were observed more frequently than halve numbers, and halve numbers in turn were observed more frequently than other fractions. A uniform distribution of prices states that about 1% of all prices are exact multiples of 10 guilders, whereas on the Dutch Stock Market it is a whopping 6.5%. Figure 2 shows the clustering described above.
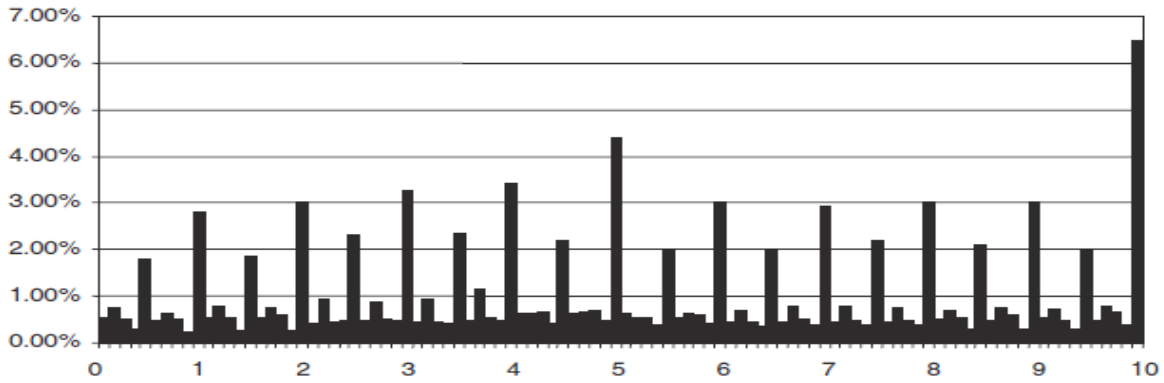
Figure 2: Taken from "Price clustering and natural resistance points in the Dutch Stock Market: A natural experiment by Joep Sonnemans, (2006).

In the euro years again whole number clustering seemed to be common with peaks at 0 and 5. The tick size here was 1eurocent, but for practical reasons a tick size of 10 eurocents was used in the following figure (figure 3), which provides the evidence for price clustering between 1999 and 2001.
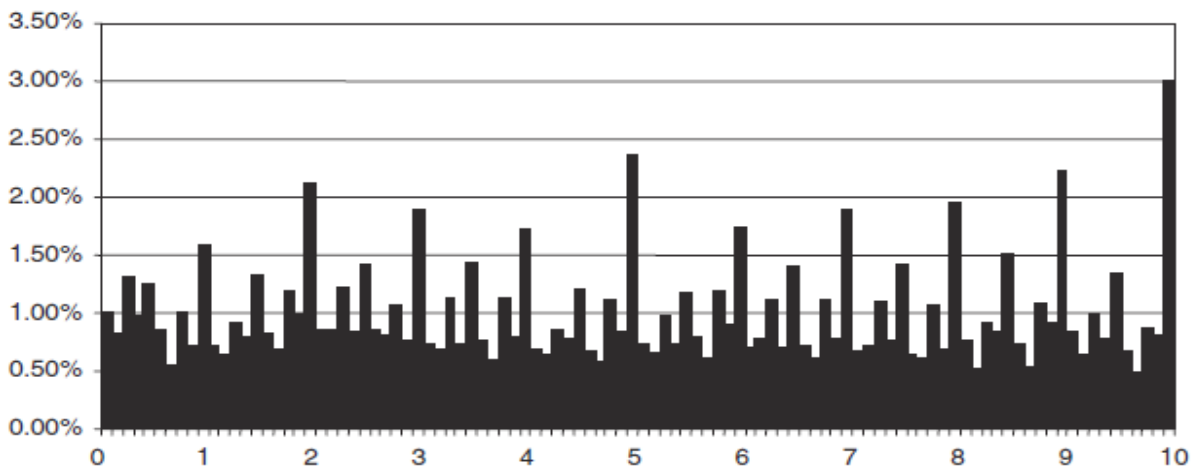

Figure 3: Taken from "Price clustering and natural resistance points in the Dutch Stock Market: A natural experiment by Joep Sonnemans, (2006).

Last but not least figure 4 shows the price distribution between 19991 and 2001 converted from euros to guilders, which relative to figure 2 and 3 shows a uniform distribution. This is a cutting contrast to the individual figure for euros and guilders.
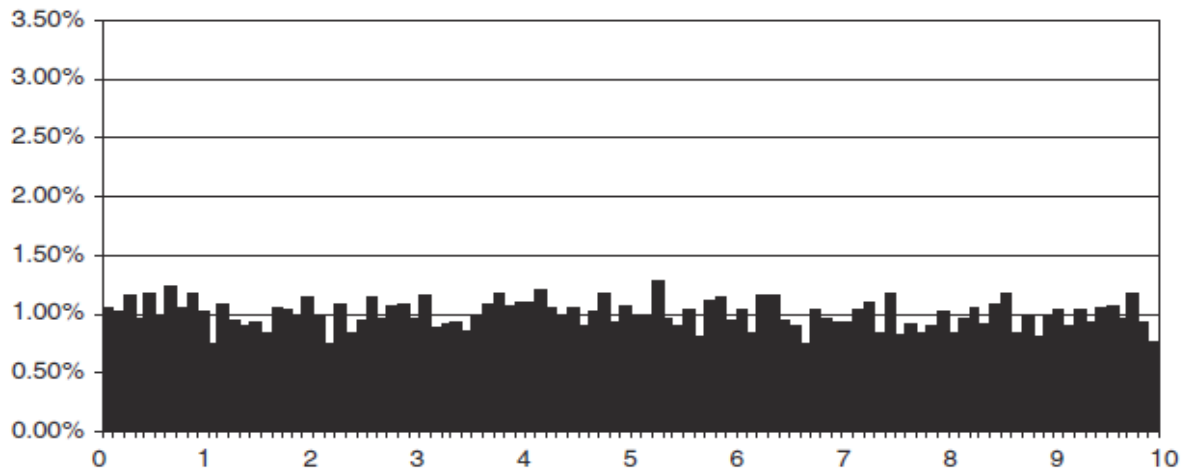
Figure 4: Taken from "Price clustering and natural resistance points in the Dutch Stock Market: A natural experiment by Joep Sonnemans, (2006).

To conclude it is important to give a clear overview. Round number effects were found in the guilder years (1990-1998) and in the euro years (1999-2001), but not for guilders in the euro years. In line with the odd price hypothesis the change after January 1st 1999 is radical. This change however is not consistent with the aspiration level hypothesis.

3.1.4 China, emerging market

Yan he and Chunchi Wu looked into the domestic and foreign shares traded on the Shanghai and Shenzhen Stock Exchanges in China which is considered a developing (emerging) market. It has been found in the past that prices tend to cluster for the economic reasons mentioned before, all of which are assumed to be relevant for developed markets. He and Wu expected the same reasoning behind the clustering on the Shanghai and Shenzhen Stock Exchange and thus that prices would cluster a lot on 5s and 10s. They also suspected however, that there would be a cultural influence on the price clustering in China. Namely, clustering at the number "8" as this represents a lucky number because it has the same pronunciation as making a fortune or getting rich ("Fa" in Cantonese). In other words, the "8" is most popular in the business community and is associated with financial wealth. In short, He and Wu expected that the domestic shares would be rounded on 5s and 10s for economic reasons and on 8s for cultural reasons. Also the foreign shares would be rounded on 5s and 10s, but not on 8s, as the latter is typical for China and thus Chinese domestic shares.

He and Wu collected daily data for stocks traded on the Exchanges from January 1st 1998 to December 31st 2000. Under the firms that traded domestic shares, they selected the stocks on the basis of them having trading record throughout the entire sample period and close prices larger than one Chinese Yuan. In addition to that they selected firms that were traded in both domestic and foreign shares. Each stock in the sample was subject to daily data being collected, including daily numbers of shares transacted, daily amount of money transacted, end-of-day closing price, last bid and ask prices of each trading day, market capitalization etc. Based on this data, He and Wu estimated rounding frequency for close, ask and bid prices (5-cent and 10-cent rounding).

They found that indeed the close, bid and ask prices of domestic shares are rounded at the nearest 5s and 10s, specifically, the frequency for 100-cent rounding is larger than 1%, for 50-cent rounding it's larger than 2%, for 25-cent rounding it's larger than 4% , for 10-cent rounding it's larger than 10% and the frequency of 5-cent rounding is greater than 20%. The difference between the frequency of the uniform distribution and the observed frequency of a certain price clustering were found to be significant at the 5% level. Figure 2 provides the evidence to show that the frequency for prices ending (last decimal point) in 0, 5 or 8 is relatively higher than the frequency of a price ending in for example 4. He and Wu found the clustering occurs on 5s and 10s because of economic reasons and on 8s for cultural reasons. The foreign share prices clustered on 5s and 10s, but not on 8s as expected, because foreign shares are not subject to the number superstition that haunts the domestic shares. Remarkable was also their finding that the rounding frequency on 5s and 10s were in general lower on the Chinese markets than in the NYSE, which could be the result of the difference of level of stock market development between the two countries. Specifically, on the NYSE Harris reports that 15% to 30% of the total trades of stock prices between 10 and 100 currency units, are performed in round integers. Meanwhile, only about 3% to 6% of trades are transacted on round integers for stock prices between 20 and 40 units of Chinese Currency Yuan on the Shanghai and Shenzhen Stock Exchange. This is the first notable difference between a developed and emerging Stock Market (He & Wu, 2006).
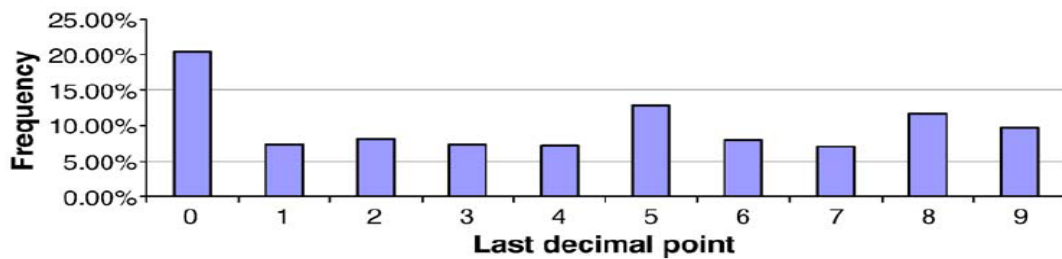
Figure 5: Taken from "Is stock price rounded for economic reasons in the Chinese markets?" by Yan He, Chunchi Wu, (2006).

Brown and Mitchell did a similar investigation into the Shenzhen and Shanghai Stock Exchange. Just like He and Wu they stated that the number 8 is considered "lucky" in China, and is thus very attractive to many Chinese. In addition to that, the number 4 is considered to be "unlucky". They lead a tightly controlled experiment to check if a preference for numbers based on cultural factors exists. The sample period was 1994-2002 and showed that for the A-shares (mostly held by Chinese individuals or organizations) the prices ended in 8 more than twice as likely, than in 4. Initially, the preference for 8 was quite strong, but overtime this preference has fainted. For the B-shares (mostly held by foreigners) the preference for 8 was notably weaker. This is consistent with the findings of He and Wu (Brown & Mitchell, 2008).

3.1.5 Mexico, emerging market

Narayan et al. (2011) conducted another study on price clustering on The Mexican Stock Exchange market known as the Bolsa Mexicana de Valores (BMV), which is the second largest Stock Exchange in Latin America. Research in this area is still scarce, as only a handful of studies have been conducted. The BMV is also considered an emerging market; however it is in some aspects different than other emerging markets such as China and India (not mentioned in this paper), because the latter have significant influences from terrorism, sporting events and cultural factors on their markets. Thus, they saw this research as a "fresh look" on the matter. Estimated total value of this Stock Exchange is

over $600 billion. The BMV trades among other, development bank bonds, commercial paper, promissory notes, debt instruments, federal government development bonds, investment unit bonds and banker acceptance. Stocks, debentures, mutual fund shares and warrants are also traded on this Stock Exchange.

Other than the research by He and Wu, Narayan et al. looked at the twelve companies at the top of the list in the Mexican share market, rather than all the shares traded on the market. In other words, they approach the matter on a micro-level. They obtained daily data on share prices for twelve companies from Bloomberg, whom were listed as Mexico's largest. The companies researched were AMXL, WALMEXV, TELECOA1, CEMEXCP, TLEVICPO, GMEXICOB, GFINBURO, ELEKTRA, GCARSOA1, FEMSAUBD, PE&OLES and GFNORETO. The date is for the period 2003-2008, as there is no consistent daily data available before 2003 and the period beyond 2008 might be victim of the rise in oil price, which might distort the results. By means of a standard probit model, with the dependent variable being a binary variable with value one if prices cluster on x.00 or x.05 and a value zero otherwise, they conducted their tests.

Research into the price clustering phenomenon benefits from the approach of Narayan et al., because it allows for a comparison of companies that differ in terms of their mean share prices and volatility. It would be interesting to see whether price clustering occurs in a different set of companies. Also, whether the heterogeneity of the firms means that price, volume and volatility have a similar impact as when firms are a lot alike.

The main conclusions that Narayan et al. found were that nine out of the twelve companies experiences price clustering (prices ending in .00 and .05). The remaining three companies were the smallest companies in terms of mean share price, which is consistent with the idea that the higher the share (stock)

price, the higher the chance for clustering. Because the highest clustering found, was for the companies with the highest mean price. Secondly, they found that volume and own share price volatility have a negative effect on clustering, which is consistent with the price negotiation/resolution hypotheses. These hypotheses, introduced by Harris (1991) and Christie and Schultz (1994), state that a greater frequency of clustering is expected when the costs of negotiations are highest and/or the benefits lowest (Christie & Schultz, 1994).

It could be said that higher volume could be linked to a firm being bigger, which means there is less uncertainty and hence less clustering (negative relationship as found). Lastly they found that there is a negative effect between own share price and price clustering, which is inconsistent with the basic theory. The thought behind this could be that in Mexico, market agents are more concerned about the finer partitions of price, which is the second difference when comparing to a developed Stock Market. Narayan et al. concluded from this that the agents on Stock Markets in Mexico behave differently than the ones in developed countries. Prices in Mexico tend to be very unstable because the country has been victim of several devaluation periods, which could also be a reason (Narayan, Narayan, Popp, & D'Rosario, 2011).

3.1.6 Singapore, emerging market

Last but not least The Singapore Stock Market (SES) which is one of the most popular emerging markets is considered. Hameed and Terry (1998) ran the research into the SES, which consists of mainly four sections. Large, more established companies trade their shares on the main board of the SES. Smaller local firms who unfortunately cannot be considered for the main board, trade on the SESDAQ, which is the SES Dealing and Automated Quotation System modeled after the well known NASDAQ. Smaller foreign firms, especially from Malaysia, trade their shares on CLOB international. Finally, the SES-NASDAQ link

eases the trading across the two markets. Hameed and terry chose to focus on the main board trading, which is an order-driven market. Important to state is that they predicted that tick size is the reason behind clustering.

Data used for their research consisted of the daily high, low and closing transaction prices plus daily volume. All for the shares listed on the main board of the SES. The relevant period is from January 1980 to July 1994. The sample is split up in different price ranges, where a stock is included in a specific price range if at least thirty prices were within that range over the entire period at closing. Table 1 shows that most of the prices were in the lowest categories of price ranges. From the 234 stocks in the sample, only 5 had a closing price higher than $25 throughout the sample, which is why the two highest categories were later removed from the analysis.

Summary Statistics for the Initial SES Stock Sample by Price Range

| Variable | Price Range | | | | |
	$0.005 −$1.00	$1.01 −$3.00	$3.02 −$5.00	$5.05 −$10.00	$10.10 −$25.00
Number of stocks	118	191	125	74	35
Daily volume					
Mean	170.17	231.58	196.93	134.66	171.22
Median	69.94	114.98	88.56	87.85	131.71
Daily volatility					
Mean	0.0213	0.0207	0.0189	0.0191	0.0237
Median	0.0196	0.0203	0.0175	0.0183	0.0210
Closing Price					
Mean	$0.768	$1.858	$3.763	$6.502	$12.812
Median	$0.780	$1.864	$3.738	$6.378	$12.579

Table 1: Taken from "The effect of tick size on price clustering and trading volume" by Allaudeen Hameed and Eric Terry, (1998). Daily volume is measured

In thousands of shares traded daily; daily volatility by the log ratio of the faily high and low prices.

Hameed and Terry found evidence for price clustering in all five categories. For the first category, prices ending in 0s were most common. More specifically, prices ending in even cents were observed more frequent than prices ending in odd cents. For the remaining categories the same results were observed. One difference compared to previously done studies was that prices ending in twenty-five and/or seventy-five cents were not observed on the SES (Hameed & Terry, 1998).

3.2 Comparison

The first notable difference between a developed and emerging stock market became clear when looking at the Shenzhen and Shanghai Stock Exchange and the NYSE. The rounding frequency on the former is notably less than on the latter. Harris reported that on the NYSE about 15% to 30% of total trades in stock prices between 10 and 100 currency units were performed on round integers, whereas only about 3% to 6% of total trades in stock prices between 20 and 40 currency units were performed on round integers on the Shenzhen and Shanghai Stock Exchange.

On the Bolsa Mexicana de Valores, Narayan et al. (2011) found the interesting fact that inconsistent with theory (price negotiation/resolution hypotheses), own stock price level and volatility had a negative effect on stock price clustering. An idea behind this was that agents on the Mexican Stock Market might be more concerned about the finer partitions of the price compared to the agents on developed stock markets. Prices in Mexico have been victim to a lot of devaluations throughout the years, which makes them relatively unstable. You could say that the latter is linked to the theory by Ball et al. that it is the extent to which the underlying value of a security is known that is the reason behind price clustering. Because they found that the rate of price resolution depends on the sum of information in the market, the level of the price and the variation of the price. If a country is victim of several devaluations, the variation of the price, the price level itself and the information in the market are all very uncertain and change a lot over time.

Although Singapore did not perform notably different than other developed markets, one explanation behind this could be the one given by Levine et al. that despite being considered an emerging market, Singapore still is highly developed compared to other underdeveloped markets. Such are Hong Kong,

the Republic of Korea, Switzerland and Malaysia, which all have highly developed markets compared to very underdeveloped markets such as Turkey, Greece, Pakistan and Argentina (Demirguc-Kunt & Levine, 1994).

3.3 Discussion

A few (behavioral) explanations behind the price clustering phenomenon are noted by Sonnemans. The main one is that Individuals obviously tend to have a preference for round numbers, which is a commonly used theory in Behavioral Economics courses. This prompts them to trade at round number prices. Heath et al. also argued an idea that goals serve as reference points, which alter outcomes in a way that is consistent with the well known value function of Prospect Theory by Kahneman & Tversky. It states that people tend to underweight probabilities of events that happen with quite high certainty. This is called the certainty effect and contributes to risk aversion in choices that involve gains that are sure and risk seeking in choices that involve sure losses. In addition to that they present the isolation effect, which states that people choose inconsistently when the same choice set is presented in different forms. Also, people tend to overweight low probabilities, which make for example lotteries very attractive (Kahneman & Tversky, 1979). Heath et al. presented new evidence that goals transmit the properties of a value function. These goals not only represent a reference point, they also represent loss aversion and diminishing sensitivity (Heath, Larrick, & Wu, 1999).

Second Sonnemans touches a subject called "odd pricing", which is from the marketing literature better known as cognitive psychology. In short, it states that prices are often set just below a round number (Think of $9.99 instead of $10.00). It is a phenomenon common in the marketing of consumer goods and real estate. The reasoning behind this is that (some) individuals consider the odd price significantly lower than the round one, because people tend to process

and save numeral information in a matter that makes the first digits more valuable. First digits namely contain more information than later digits. It's called a left-to-right approach. Other than with consumer goods, customers prefer high prices for bank deposit rates, which is why it is expected for the latter to cluster on integer values. Last but not least bounded rationality theories are also considered. It states that instead of maximizing a utility function, investors look for a "good enough" solution. As investors already have a slight idea at which price they will be able to sell a stock in the future. This target price is then used by investors as an aspiration level.

Although not directly related to our topic, it is worth mentioning that economic as well as cultural factors play a role in the price clustering phenomenon. The research into the Shanghai and Shenzhen Stock Exchange in China was the first to provide evidence for this, as domestic plus foreign shares clustered on 5s and 10s, but only domestic shares clustered on 8s. Since eight is considered a lucky number in China, this was a cultural factor belonging to only China.

Chapter 4: Conclusion

To look into the phenomenon known as price clustering, a comparison based on the level of stock market development between countries was made. The price clustering phenomenon is not in line with the random walk theory that is known standard economic theory.

Harris and Niederhoffer were the first authors to look into this topic in respectively 1991 and 1965/1966. The main reasons behind this phenomenon were the fact that agents may use a discrete set if prices during negotiations to facilitate these. Harris states that own price level and volatility should have a positive relation with price clustering, while it decreases with an increase in capitalization and transaction frequency. Also, Niederhoffer stated that public limit orders are presented at round prices, which is why clustering should appear more in public auction exchanges than in dealer markets. Ball et al. state that the degree of uncertainty about the true price of a stock is positively related to clustering and last but not least, Morck et al. state that it is the extent to which markets can process information is the reason behind price clustering.

Three developed stock markets (NYSE, The Dutch Stock Exchange and The Australian Stock Exchange) were compared to three emerging markets (The Mexican Stock Exchange, The Shenzhen and Shanghai Stock Exchange from China and the Singapore Stock Exchange).

It has been shown that the frequency with which prices cluster tends to be higher in developed markets, compared to emerging markets. Moving along we also saw that agents' personal beliefs play a crucial role, as was evident in Mexico. Because of agents being more concerned about the finer partitions of prices, caused stock price clustering in a different way than basic theory. In Mexico a negative relationship was noted between own share price and price clustering.

It is safe to say that cultural factors differ between countries a lot, and there will certainly be a cultural-specific difference between developed and developing countries. More research into this matter would not be superfluous.

The price clustering phenomenon is very peculiar as it is not in line with the random walk theory we've all became familiar with. Because of this it is interesting to look into this phenomenon. Turns out it happens in quite a lot of financial markets, which is unexpected.

As there are not many papers yet that focus specifically on a country comparison based on the level of market development, further research into the matter would not be superfluous.

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