

CHAPTER 7

PSYCHOLOGICAL BARRIERS IN THE MARKETS FOR ADRS AND ETFs

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Abstract

In this chapter we study for the first time the existence of psychological barriers at round numbers in the markets for ADRs and ETFs. We perform uniformity tests, barrier hump tests, barrier proximity tests and conditional

effects tests to a sample comprised by the daily closing quotes of six of the most liquid assets in each of those two markets. Overall, we found evidence of the existence of psychological barriers in only two of the ETFs under study: Brazil and Germany ETFs. Regarding ADRs, we report strong signs of barriers for Vale and inconclusive results for the remaining assets.

Key-words: Psychological barriers; American Depositary Receipts; Exchange-Traded Funds.

1. Introduction

Psychological Barriers are currently one of the most important topics of research in the field of Behavioral Finance, with several empirical studies published since the 1990's on a variety of financial assets, such as stock indices, single stocks, bonds, derivatives and gold, among others. However, there is a lack of studies regarding the existence of psychological barriers in the ADRs and ETFs markets. This gap in the literature is surprising given the economic importance of these markets. For example, data from the Investment Company Institute shows that in 2018, almost 2,000 ETFs were listed in the US for assets worth the staggering figure of 3.4 trillion USD. Also, according to the Bank of New York Mellon, the combined trading value of listed depository receipts on US exchanges in that same year reached the value of 4.2 trillion USD.

In this chapter we examine for the first time the existence of psychological barriers in the markets for ADRs and ETFs. Our sample includes six of the most liquid assets in each of those two markets. We test for uniformity in the trailing digits of the daily closing prices and use regression and GARCH models to assess the differential impact of being above or below a possible barrier.

The results evidence the existence of psychological barriers in only three of the assets under scrutiny, being one ADR (Vale On 1:1) and two ETFs (MSCI Brazil and Horizons Capital Dax Germany). Overall, we find our results to be consistent with the efficient market paradigm presented by Fama (1970).

The remainder of this chapter is organized as follows: section 2 presents the literature review and section 3 addresses the methodological aspects, namely the data used in the study and the various methodological steps.

The fourth section discusses the empirical results and the last section concludes the chapter.

2. Literature review

2.1. Possible causes of psychological barriers

Psychological barriers can be seen as limits to arbitrage provoked by mental biases. Mitchell (2001) pointed out that a psychological barrier can be viewed as an impediment to an individual's mental outlook, that is, an obstacle created by the mind, barring advance or preventing access. The decisional bias of anchoring, that is, the tendency exhibited by most people to make estimates by starting from an initial value and then adjust, most of the times insufficiently (Tversky and Kahneman, 1974), can be at the root of psychological barriers. Westerhoff (2003) used anchoring to develop a model that produces persistently misaligned exchange rates which move within the limits of a fluctuation band. These limits function as support and resistance levels, that is, as psychological barriers.

Aspiration levels, a concept of psychological theory which was introduced to economic theory by Simon (1955) alongside the notion that the economic agent might not pursue the optimal solution but actually settle for a satisfactory solution, can also be one of the causes of psychological barriers. Sonnemans (2006) noted that some investors, when buying a stock, already have an idea for what price they will be able to sell the stock in the future. Additionally, some financial analysts also use target prices for individual stocks and these are also typically round numbers (Sonnemans, 2006), which will lead to many limit sell offers being posted at round whole numbers.

Psychological barriers can be provoked by odd pricing as well. According to Sonnemans (2006, p. 1938), “odd pricing is the tendency of consumers to consider an odd price like 19.95 as significantly lower than the round price of 20.00”. This tendency could be originated by the limited amount of memory that people have, which leads them to attach more significance to the first digits of a price as they contain more significant information than the last digits (Brenner and Brenner, 1982). Odd pricing is very common in consumer goods, with a number of studies (e.g., Holdershaw *et al.*, 1997; Folkertsma, 2002) showing that prices tend to have 9 as the last significant digit.

Finally, psychological barriers could be caused by the fact that option exercise prices are usually round numbers (Dorffleitner and Klein, 2009). Delta hedgers are frequently most active when the price of the underlying is close to the exercise price – in other words, when the option is at the money – so, purely technical reasons can also cause additional trading activity in the underlying asset.

2.2. Previous empirical studies

The first empirical studies on psychological barriers were performed in the early 1990's and focused mainly on stock indices. In this section, for brevity reasons, we highlight those studies about psychological barriers in stock indices and single stocks, putting aside other studies applied to bonds, derivatives, commodities or cryptocurrencies (some examples are, respectively, Burke, 2001; Schwartz *et al.*, 2004; Agarwal and Lucey, 2007; Fonseca *et al.*, 2019).

Donaldson and Kim (1993) tested whether DJIA's movements around key reference points exhibited psychological barriers during the period 1974-1990, finding that those movements were indeed restrained by support and resistance levels at multiples of 100. After breaking through a 100-level, the DJIA moved by more than otherwise warranted. Ley and Varian (1994) also studied the DJIA, with a wider time interval (1952-1993), and confirmed the non-uniformity of the distribution but added that there is no predictive power on the daily closing prices resulting from psychological barriers.

Koedijk and Stork (1994) tested the existence of psychological barriers in five major stock markets (from Belgium, Germany, Japan, the US and the UK) between 1980 and 1992. Their results corroborated the conclusions from the previous studies: psychological barriers are real, but they do not imply predictability of stock returns.

Cyree *et al.* (1999) extended the analysis to six foreign stock indices, alongside the DJIA and the S&P 500, and controlled for the separate and potentially offsetting effects of crossing barriers from below and above. Their findings support the existence of psychological barriers and show that these effects are particularly pronounced when the barrier is approached from below.

Bahng (2003) conducted the first study about this topic on Asian stock markets, using the daily prices of seven indices. The Taiwanese index and the Indonesian index exhibited some signs of psychological barriers.

Dorfleitner and Klein (2009) focused on European stock indices, namely the German DAX 30, the French CAC 40, the British FTSE 50 and the Euro-zone related DJ EURO STOXX 50. They found only fragile traces of psychological barriers in all indices at the 1000s barrier level and also indications of barriers at the 100-barrier level, except in the CAC 40.

Shawn and Kalaichelvan (2012) tested the existence of psychological barriers in five European stock indices. They only found evidence for barriers in the main Switzerland stock index at the 1000 level.

More recently, Woodhouse *et al.* (2016) found evidence of psychological barriers at the 100 level in the NASDAQ and Lobão and Pereira (2017) analyzed the main Southern European stock markets (Greece, Italy, Portugal and Spain) to conclude that only the Iberian markets exhibited strong indication of barriers. Finally, Lobão and Fernandes (2018) found no consistent psychological barriers in individual stock prices near round numbers in the markets of Taiwan, Brazil and South Africa.

3. Data and methodology

3.1. Data

The sample considered in the study includes six of the most liquid ADRs and six of the most liquid ETFs. The ADRs included in our sample were Alibaba 1:1, Nokia 1:10, Novartis 1:1, Royal Dutch Shell 1:2, Vale On 1:1 and Teva Pharmaceuticals 1:1 and the ETFs considered were iShares MSCI Brazil, Horizons Capital Dax Germany, iShares MSCI Japan, iShares MSCI South Africa, iShares Russell 1000 and SPDR S&P 500. We collected the daily closing quotes for each asset for the period between January 1, 2008 and December 31, 2017. The exceptions were Alibaba ADR and the Germany ETF since the first trading day of these two assets occurred after January 1, 2008. Thus, for those assets the start date of the data is the first trading day. All the data were collected from Thomson Reuters Datastream.

Table 1 presents the descriptive statistics of the assets included in the sample with the denomination which will be used from now on for each asset. The table shows that in the period under analysis ADRs and ETFs provided mean returns close to zero.

Table 1 – Descriptive statistics

Market	Asset	Start Date	End Date	N	Return Series				Level Series	
					Mean	Std Dev	Skewness	Kurtosis	Min.	Max.
ADR	Alibaba	Sep 19, 2014	Dec 31, 2017	856	0.0711	1.9133	0.2348	3.7718	57.39	191.19
	Nokia			2609	-0.0809	2.9127	-0.3293	9.5049	1.69	38.39
	Novartis			2609	0.0167	1.2673	-0.0999	5.2864	33.96	106.12
	Shell	Jan 1, 2008		2609	-0.0075	1.8483	-0.0199	9.2449	36.96	87.92
	Teva			2609	-0.0344	1.9461	-1.6565	30.6603	11.23	72.00
	Vale			2609	-0.0377	3.3276	-0.1251	6.1480	2.15	43.91
ETF	Brazil	Jan 1, 2008	Dec 31, 2017	2609	-0.0265	2.4367	-0.3770	10.6983	17.33	100.47
	Germany	Oct 23, 2014		832	0.0270	1.1844	-0.8977	9.5630	21.46	31.91
	Japan			2609	0.0046	1.4031	0.2532	13.4178	27.48	60.62
	South Africa			2609	0.0028	2.2778	-0.2685	11.2820	25.87	76.87
	US: Russell 1000	Jan 1, 2008		2609	0.0239	1.2423	-0.3469	10.4627	37.06	149.93
	US: S&P 500			2609	0.0231	1.2601	-0.0879	14.9512	68.11	268.20

3.2. Methodology

3.2.1. Definition of barriers

Following Brock *et al.* (1992), we use the so-called band technique to define a barrier as an interval between two numbers at the same distance from the number which constitutes the actual barrier. The main reason for this technique is the idea that market players will become more active at a certain level before the price touches a round number. The barrier level l is defined as the number of zeros that a barrier has and the barrier levels $l = -1$ and $l = -2$ refer to the 0.1-level and 0.01-level barriers, respectively (Dorflleitner and Klein, 2009). We define as potential barriers the multiples of 0.01, 0.1, 1, 10, 100 and 1000 and define intervals with an absolute length of 2%, 5% and 10% to the corresponding barriers, thus considering the following restriction bands:

Barrier level $l = 3$ (1000s):	980-1020; 950-1050; 900-1100
Barrier level $l = 2$ (100s):	98-102; 95-105; 90-110
Barrier level $l = 1$ (10s):	9.8-10.2; 9.5-10.5; 9.0-11.0
Barrier level $l = 0$ (1s):	0.98-1.02; 0.95-1.05; 0.90-1.10
Barrier level $l = -1$ (0.1s):	0.098-0.102; 0.095-0.105; 0.090-0.110
Barrier level $l = -2$ (0.01s):	0.0098-0.0102; 0.0095-0.0105; 0.0090-0.0110.

For each asset, we then examine the barrier levels which are susceptible of constituting psychological barriers.

3.2.2. M-values

De Ceuster *et al.* (1998) argue that one should consider the possibility of barriers at the levels ..., 10, 20, ..., 100, 200, ..., 1000, 2000, ..., i.e. generally at:

$$k \times 10^l, k = 1, 2, \dots, 9; l = \dots, -1, 0, 1, \dots \quad (3.1)$$

and also at the levels ..., 10, 11, ..., 100, 110, ..., 1000, 1100, ..., i.e. generally at:

$$k \times 10^l, k = 10, 11, \dots, 99; l = \dots, -1, 0, 1, \dots \quad (3.2)$$

The M-values we use in our study are defined according to these barriers.

$$M_k = \left[P_t * \frac{100}{k} \right] \text{ mod } 100, k = 0.01, 0.1, 1, 10, 100, 1000 \quad (3.3)$$

where $\left[P_t * \frac{100}{k} \right]$ is the integer part of $P_t * \frac{100}{k}$ and $mod\ 100$ is the reduction modulo of 100.

Illustrating this with a purely theoretical quote of 1234.56789, the M0.01 is 78, the M0.1 is 67, the M1 is 56, the M10 is 45, the M100 is 34 and the M1000 is 23.

3.2.3. Uniformity test

After defining the M-values, the next step is to examine if they follow a uniform distribution, through the uniformity test introduced by Ley and Varian (1994), which consists of a Kolmogorov-Smirnov Z-statistic test where we will be testing H0: uniform distribution against H1: non-uniform distribution. In the presence of psychological barriers, it is expected to reject the null hypothesis. However, it is important to underline that this rejection does not by itself confirm the existence of such barriers.

3.2.4. Barrier tests

Following the literature on price barriers (e.g., Aggarwal and Lucey, 2007), we perform two barrier tests, a barrier proximity test and a barrier hump test. The purpose of these tests is to assess if the series observations on or near a barrier occur less frequently than what would be predicted by a uniform distribution.

A barrier proximity test examines the frequency of M-values in the proximity of potential barriers, applying the following equation:

$$f(M) = \alpha + \beta D + \varepsilon, \quad M = 00, 01, \dots, 99 \quad (3.4)$$

where $f(M)$ is defined as the frequency with which a quote closes with its last two digits in cell M, minus 1 percentage point, and D is a dummy variable which takes the value 1 if the price of the asset is at the potential barrier and 0 elsewhere. Besides the strict dummy, which takes the value 1 if $M=00$ and takes the value 0 otherwise, we will study three dummies for each potential barrier level:

$$D_{98-02} = 1 \text{ if } M \geq 98 \text{ or } M \leq 02, = 0 \text{ otherwise}$$

$$D_{95-05} = 1 \text{ if } M \geq 95 \text{ or } M \leq 05, = 0 \text{ otherwise}$$

$$D_{90-10} = 1 \text{ if } M \geq 90 \text{ or } M \leq 10, = 0 \text{ otherwise.}$$

The β coefficients are expected to be negative and statistically significant in the presence of psychological barriers.

The barrier hump test examines the entire shape of the distribution of M-values and is broader than the barrier proximity test as it does not focus solely on the proximity of the potential barriers. We implement this test using the following equation, which was introduced by Bertola and Caballero (1992):

$$f(M) = \alpha + \gamma M + \delta M^2 + \varepsilon, \quad M = 00,01, \dots,99 \quad (3.5)$$

where $f(M)$ is once again defined as the frequency with which a quote closed with its last two digits in cell M, minus 1 percentage point, and the independent variables are the M-value and its square.

In the presence of psychological barriers, the M-values are expected to follow a hump-shape distribution, which will be reflected in Eq. (3.5) through negative and statistically significant δ , whereas under the null hypothesis of no barriers, δ should be zero and the M-values should follow a uniform distribution.

3.2.5. Conditional effects test

The final test of our methodology was introduced by Cyree *et al.* (1999) and is designed to detect changes in the conditional mean and variance of the distribution of returns during the sub-periods before and after crossing a barrier, either from above or below. We use a 5-day window before and after crossing a barrier.

In order to identify if a barrier is crossed in an upward or downward movement and examine the difference in returns between the 5-day periods before and after the barrier is crossed, we will use four dummy variables: UB for the 5-day period before prices cross a barrier on an upward movement, UA for the 5-day period after prices cross a barrier on an upward movement, DB for the 5-day period before prices cross a barrier on a downward movement and DA for the 5-day period after prices cross a barrier on a downward movement. Each of these dummies will take the value 1 on the identified days and the value 0 elsewhere. Taking into account, as stated by Cyree *et al.* (1999), that the distributional shifts implied by psychological barriers invalidate the basic assumptions of OLS, we will then regress the following equations using a GARCH (1,1) model:

$$R_t = \beta_1 + \beta_2 UB_t + \beta_3 UA_t + \beta_4 DB_t + \beta_5 DA_t + \varepsilon_t \quad (3.6)$$

$$\varepsilon_t \sim N(0, V_t) \quad (3.7)$$

$$V_t = \alpha_1 + \alpha_2 UB_t + \alpha_3 UA_t + \alpha_4 DB_t + \alpha_5 DA_t + \alpha_6 V_{t-1} + \alpha_7 \varepsilon_{t-1}^2 + \eta_t \quad (3.8)$$

In the absence of barriers, it is expected that the coefficients of the indicator variables will take the value zero both in the mean and variance equations, whereas any coefficient significantly different from zero (either positive or negative) will indicate the presence of psychological barriers.

The four null hypotheses to be tested using a Wald test are the following:

H1: There is no significant difference in the conditional mean return before and after an upwards crossing of a barrier;

H2: There is no significant difference in the conditional mean return before and after a downwards crossing of a barrier;

H3: There is no significant difference in the conditional variance before and after an upwards crossing of a barrier;

H4: There is no significant difference in the conditional variance before and after a downwards crossing of a barrier.

4. Empirical results

4.1. Uniformity test

Table 2 shows the results of the uniformity tests for each financial asset, using a Kolmogorov-Smirnov Z-test which studies the distribution of the M-values for a total of 12 financial assets and 28 potential barriers. Overall, the financial assets exhibit signs of psychological barriers, as there are statistically significant evidence at a 5 percent significance level that M-values do not follow a uniform distribution for, at least, one barrier level for all the 12 assets and for, at least, two barrier levels for 8 of the 12 assets under study (the exceptions are the Shell and Vale ADRs and the Germany and South Africa ETFs).

Table 2 – Uniformity test results

			M1	M10	M100
ADR	Alibaba	Z Stat.	2.640853	0.916470	10.43078
		p-value	0.0000***	0.3704	0.0000***
	Nokia	Z Stat.	1.962082	9.355578	--
		p-value	0.0009***	0.0000***	--
	Novartis	Z Stat.	1.205620	2.498224	18.51664
		p-value	0.1093	0.0000***	0.0000***
Shell	Z Stat.	1.948468	1.264737	--	
	p-value	0.0010***	0.0816*	--	
Teva	Z Stat.	1.822424	1.809143	--	
	p-value	0.0026***	0.0029***	--	
Vale	Z Stat.	1.295465	4.072440	--	
	p-value	0.0697*	0.0000***	--	
ETF	Brazil	Z Stat.	1.659428	2.532433	--
		p-value	0.0081***	0.0000***	--
	Germany	Z Stat.	0.827227	4.759643	--
		p-value	0.5005	0.0000***	--
	Japan	Z Stat.	3.402057	6.867324	--
		p-value	0.0000***	0.0000***	--
South Africa	Z Stat.	1.292552	2.480497	--	
	p-value	0.0708*	0.0000***	--	
US: Russell 1000	Z Stat.	1.625609	1.629835	5.100530	
	p-value	0.0101**	0.0099***	0.0000***	
US: S&P 500	Z Stat.	1.150749	3.205473	10.35219	
	p-value	0.1415	0.0000***	0.0000***	

Table 2 presents the results of a Kolmogorov-Smirnov test for uniformity. Z-stat stands for the value of the test statistic; p-value shows the marginal significance of this statistic. H0: uniformity; H1: non-uniformity. Significance at the 10%, 5% and 1% levels are denoted respectively *, ** and ***.

The Nokia and Teva ADRs, the Brazil, Japan and Russel 1000 ETFs reject uniformity at a 5 percent significance level for every potential barrier level. The results of this test do not show any significant differences between the two types of financial assets under study.

4.2. Barrier tests

4.2.1. Barrier proximity test

Tables 3 to 6 contain the results of the barrier proximity tests performed on the selected ADRs and ETFs. As previously mentioned, in the presence of a psychological barrier it is expected that β is negative and significant, which means that there is a lower frequency on the M-values around round numbers.

Table 3 – Barrier proximity test results for the strict dummy

	M1			M10			M100		
	β	p-value	R ²	β	p-value	R ²	β	p-value	R ²
ADR									
Alibaba	2.6480	0.0000***	0.3834	-0.1841	0.6267	0.0024	0.2879	0.7885	0.0007
Nokia	0.0739	0.7611	0.0009	-0.3906	0.5317	0.0040	--	--	--
Novartis	0.1901	0.3544	0.0088	-0.0809	0.7601	0.0010	-0.4681	0.6683	0.0019
Shell	0.6547	0.0023***	0.0908	0.2288	0.2976	0.0110	--	--	--
Teva	0.8870	0.0002***	0.1294	0.7708	0.0020***	0.0936	--	--	--
Vale	0.1127	0.5408	0.0038	0.2675	0.3547	0.0087	--	--	--
ETF									
Brazil	0.3062	0.1440	0.0217	-0.0422	0.8589	0.0003	--	--	--
Germany	-0.1603	0.7100	0.0014	-0.7673	0.2279	0.0148	--	--	--
Japan	2.3969	0.0891*	0.0292	0.2288	0.5432	0.0038	--	--	--
South Africa	-0.0035	0.9853	0.0001	-0.1971	0.3305	0.0097	--	--	--
US: Russell 1000	-0.0035	0.9852	0.0001	-0.2745	0.1403	0.0221	-0.2358	0.7345	0.0012
US: S&P 500	0.0739	0.6800	0.0017	0.3062	0.1506	0.0210	0.3062	0.6148	0.0026

Table 3 shows the results of a barrier proximity test using the regression $f(M) = \alpha + \beta D + \varepsilon$, where the dependent variable is the frequency of appearance of M -values, minus 1 percentage point, and D is a dummy variable that takes the value 1 if $M=0$ and 0 otherwise (see section 3.2.4. for further details). $H_0: \beta=0$; $H_1: \beta<0$. Significance at the 10%, 5% and 1% levels are denoted respectively *, ** and ***.

Table 4 – Barrier proximity test results for the 98-02 dummy

	M1			M10			M100		
	β	p-value	R ²	β	p-value	R ²	β	p-value	R ²
ADR									
Alibaba	0.4722	0.0153**	0.0585	-0.0935	0.5886	0.0030	0.3492	0.4755	0.0052
Nokia	0.0286	0.7965	0.0007	-0.5039	0.0751*	0.0320	--	--	--
Novartis	-0.0682	0.4672	0.0054	0.0771	0.5237	0.0042	-0.2780	0.5772	0.0032
Shell	0.0851	0.3959	0.0074	0.0367	0.7150	0.0014	--	--	--
Teva	0.3514	0.0016***	0.0974	0.4321	0.0001***	0.1412	--	--	--
Vale	0.1174	0.1610	0.0199	-0.0198	0.8812	0.0002	--	--	--
ETF									
Brazil	0.0206	0.8306	0.0005	-0.1327	0.2188	0.0154	--	--	--
Germany	0.1872	0.3403	0.0093	-0.8755	0.0021***	0.0925	--	--	--
Japan	-0.0843	0.8965	0.0002	0.4967	0.0031***	0.0855	--	--	--
South Africa	0.0125	0.8852	0.0002	0.0286	0.7572	0.0010	--	--	--
US: Russell 1000	0.0690	0.4209	0.0066	-0.1085	0.2022	0.0165	-0.3667	0.2464	0.0137
US: S&P 500	0.0609	0.4563	0.0057	0.0044	0.9638	0.0001	-0.0198	0.9433	0.0001

Table 4 shows the results of a barrier proximity test using the regression $f(M) = \alpha + \beta D + \varepsilon$, where the dependent variable is the frequency of appearance of M -values, minus 1 percentage point, and D is a dummy variable that takes the value 1 if $M \geq 98$ or $M \leq 02$ and 0 otherwise (see section 3.2.4. for further details). H0: $\beta=0$; H1: $\beta < 0$. Significance at the 10%, 5% and 1% levels are denoted respectively *, ** and ***.

Table 5 – Barrier proximity test results for the 95-05 dummy

	M1			M10			M100		
	β	p-value	R ²	β	p-value	R ²	β	p-value	R ²
ADR									
Alibaba	0.2129	0.1199	0.0245	-0.0496	0.6801	0.0017	0.5828	0.0854*	0.0299
Nokia	0.0274	0.7227	0.0013	-0.6342	0.0010***	0.1044	--	--	--
Novartis	-0.0235	0.7199	0.0013	-0.0235	0.7807	0.0008	-0.3680	0.2884	0.0115
Shell	0.0353	0.6140	0.0026	0.0040	0.9550	0.0001	--	--	--
Teva	0.1958	0.0122**	0.0623	0.4033	0.0000***	0.2535	--	--	--
Vale	0.0666	0.2545	0.0132	-0.1487	0.1041	0.0267	--	--	--
ETF									
Brazil	0.0588	0.3796	0.0079	-0.1331	0.0755*	0.0319	--	--	--
Germany	0.1532	0.2622	0.0128	-0.8167	0.0000***	0.1658	--	--	--
Japan	0.0392	0.9309	0.0001	0.3524	0.0026***	0.0888	--	--	--
South Africa	-0.0509	0.3983	0.0073	0.0392	0.5435	0.0038	--	--	--
US: Russell 1000	0.0509	0.3935	0.0074	-0.0078	0.8959	0.0002	-0.3484	0.1128	0.0255
US: S&P 500	0.0783	0.1676	0.0193	0.0431	0.5264	0.0041	0.0979	0.6128	0.0026

Table 5 shows the results of a barrier proximity test using the regression $f(M) = \alpha + \beta D + \varepsilon$, where the dependent variable is the frequency of appearance of M -values, minus 1 percentage point, and D is a dummy variable that takes the value 1 if $M \geq 95$ or $M \leq 05$ and 0 otherwise (see section 3.2.4. for further details). H0: $\beta=0$; H1: $\beta < 0$. Significance at the 10%, 5% and 1% levels are denoted respectively *, ** and ***.

Table 6 – Barrier proximity test results for the 90-10 dummy

	M1		M10		M100	
	β	p-value	β	p-value	β	p-value
ADR						
		R ²		R ²		R ²
Alibaba	0.1848	0.0783*	0.0313	0.8336	0.0005	0.0268
Nokia	-0.0044	0.9414	0.0001	0.0000***	0.2539	--
Novartis	-0.0506	0.3129	0.0104	0.0401**	0.0423	0.0402
Shell	0.0141	0.7928	0.0007	0.8337	0.0005	--
Teva	0.1273	0.0348**	0.0447	0.0000***	0.2847	--
Vale	0.0442	0.3258	0.0099	0.0071***	0.0715	--
ETF						
Brazil	0.0511	0.3199	0.0101	0.0108**	0.0644	--
Germany	0.0745	0.4789	0.0051	0.0001***	0.1405	--
Japan	-0.0783	0.8214	0.0005	0.0056***	0.0756	--
South Africa	-0.0113	0.8073	0.0006	0.1730	0.0189	--
US: Russell 1000	0.0072	0.8757	0.0003	0.7193	0.0013	0.0296
US: S&P 500	0.0210	0.6308	0.0024	0.4493	0.0059	0.0008***
					0.4854	0.0870*

Table 6 shows the results of a barrier proximity test using the regression $f(M) = \alpha + \beta D + \varepsilon$, where the dependent variable is the frequency of appearance of M -values, minus 1 percentage point, and D is a dummy variable that takes the value 1 if $M \geq 90$ or $M \leq 10$ and 0 otherwise (see section 3.2.4. for further details). H0: $\beta=0$; H1: $\beta < 0$. Significance at the 10%, 5% and 1% levels are denoted respectively *, ** and ***.

Regarding the ADRs, we observe that considering a barrier in the exact zero modulo point (Table 3), none of the selected assets present negative and significant estimates for β for any barrier level; we find some negative β estimates, namely for Alibaba, Nokia and Novartis, but all of them have p-values over 10% and it is not possible to reject uniformity at the conventional significance levels. When we consider a barrier in the 98-02 interval (Table 4), the findings are almost the same, the only exception being Nokia, which presents a negative estimate for β for the 10-level barrier, now significant at a 10 percent significance level. Assuming a barrier in the 95-05 interval (Table 5), once again the only negative and significant estimate for β is that of Nokia for the 10-level barrier, which is now significant at a 1 percent level. Finally, for the 90-10 interval barrier (Table 6), we find negative and significant β estimates for Nokia at the 10-level barrier – significant at a 1 percent level – for Novartis at the 10 and 100-level potential barriers – both significant at a 5 percent level – and for Vale at the 10-level barrier – significant at a 1 percent level.

Summing up, we cannot reject the no-barrier hypothesis for Alibaba, Shell and Teva at any potential barrier level, whereas we find some signs of the existence of psychological barriers for Nokia around the 10-level round numbers, Novartis around the 10-level and 100-level round numbers and Vale around the 10-level round numbers.

As for the ETFs, Table 3 shows that none of them have negative and significant β estimates for any barrier level if we consider a barrier in the exact zero modulo point. Assuming a 98-02 interval barrier (Table 4), the Germany ETF is the only one which seems to reject the no-barrier hypothesis, for the 10-level barrier, with a negative estimate for β that is significant at 1 percent significance level. Widening the interval to 95-05 (Table 5), we find negative and significant β estimates for Brazil and Germany, both at the 10-level barrier, statistically significant at 10 percent and 1 percent level, respectively. Finally, assuming a barrier in the 90-10 interval (Table 6), we find three negative and significant β estimates: Brazil at the 10-level barrier, significant at a 5 percent level; Germany at the 10-level barrier, significant at a 1 percent level; and Russell 1000 at the 100-level barrier, significant at a 10 percent level.

Overall, concerning the ETFs, we cannot reject the no-barrier hypothesis for Japan, South Africa and S&P 500 for any potential barrier level; on the other hand, we find some signs of the existence of psychological barriers for Brazil and Germany around the 10-level round numbers and Russell 1000 around the 100-level round numbers.

4.2.2. Barrier hump test

The barrier proximity test examines the entire shape of the distribution of M-values. As explained in Section 3.2.4, in the presence of barriers δ is expected to be negative and significant. Tables 7 and 8 show the results of these tests on the selected ADRs and ETFs, respectively.

In the case of the ADRs, we find evidence of a hump-shape distribution of M-values for Nokia, Novartis and Vale at the 10-level barrier, as well as for Novartis at the 100-level barrier. These are precisely the four potential barriers that presented negative and significant β estimates – therefore suggesting the presence of psychological barriers – in the barrier proximity test. We find only one other estimate which is negative but not significant at any confidence level: Alibaba at the 10-level barrier; all the other δ estimates are positive.

As for the ETFs, we only find evidence that M-values follow a hump-shape distribution for Brazil and Germany, both at the 10-level barrier. Therefore, from the trio of potential barriers which presented signs of the existence of psychological barriers around round numbers we drop the Russell 1000 at the 100-level barrier, which actually presents a negative estimate but with a p-value higher than all the confidence levels used in our study; the same happens with Japan and South Africa at the 1-level barrier and Russell 1000 at the 10-level barrier.

In general, the results of these tests seem to be consistent with the evidence produced by the barrier proximity test. We have found consistent signs of psychological barriers around round numbers for three of the six selected ADRs – Nokia, Novartis and Vale –, as well as for two of the six selected ETFs – Brazil and Germany.

Table 7 – Barrier hump test results for the selected ADRs

	M1			M10			M100		
	δ	p-value	R ²	δ	p-value	R ²	δ	p-value	R ²
Alibaba	0.000138	0.0153**	0.065869	-1.54E-05	0.7618	0.000974	0.000575	0.0000***	0.333027
Nokia	4.59E-05	0.1560	0.026924	-0.000575	0.0000***	0.575686	--	--	--
Novartis	3.27E-06	0.9052	0.011650	-9.73E-05	0.0039***	0.138839	0.000425	0.0009***	0.276687
Shell	1.17E-05	0.6919	0.001627	-5.59E-06	0.8494	0.008225	--	--	--
Teva	6.74E-05	0.0421**	0.043547	0.000187	0.0000***	0.375537	--	--	--
Vale	3.32E-05	0.1783	0.018617	-0.000160	0.0000***	0.188277	--	--	--

Table 7 shows the results of a barrier hump test using the regression $f(M) = \alpha + \gamma M + \delta M^2 + \varepsilon_t$, where the dependent variable is the frequency of appearance of M -values, minus 1 percentage point, regressed to the said M -values and the respective squares. (see section 3.2.4. for further details). H0: $\delta=0$; H1: $\delta<0$. Significance at the 10%, 5% and 1% levels are denoted respectively *, ** and ***.

Table 8 – Barrier hump test results for ETFs

	M1			M10			M100		
	δ	p-value	R ²	δ	p-value	R ²	δ	p-value	R ²
Brazil	3.02E-05	0.2834	0.0172	-0.000136	0.0000***	0.1910	--	--	--
Germany	5.37E-05	0.3520	0.0090	-0.000454	0.0000***	0.3485	--	--	--
Japan	-3.26E-05	0.8639	0.0029	0.000169	0.0000***	0.3816	--	--	--
South Africa	-1.64E-06	0.9483	0.0154	1.57E-05	0.5538	0.0566	--	--	--
US: Russell 1000	7.26E-06	0.7731	0.0059	-4.03E-05	0.1048	0.0359	-8.10E-05	0.3837	0.0111
US: S&P 500	7.37E-06	0.7591	0.0030	2.41E-05	0.3865	0.0651	0.0003	0.0001***	0.4016

Table 8 shows the results of a barrier hump test using the regression $f(M) = \alpha + \gamma M + \delta M^2 + \varepsilon$, where the dependent variable is the frequency of appearance of M -values, minus 1 percentage point, regressed to the said M -values and the respective squares. (see section 3.2.4. for further details). H0: $\delta=0$; H1: $\delta<0$. Significance at the 10%, 5% and 1% levels are denoted respectively *, ** and ***.

4.3 Conditional effects test

Tables 9-11 present the results of the conditional effects test, where we examine the behavior of the selected financial assets' prices in the 5-day period before and after crossing a barrier from below (thus constituting a potential resistance level), and also in the 5-day period before and after crossing a barrier from above (thus constituting a potential support level).

We perform this test for one potential barrier level only for each asset, chosen as the most likely to constitute an actual barrier level, according to the results from the previous tests. Therefore, regarding ADRs, the conditional effects test is applied to the 10-level barrier for Nokia, Shell, Teva and Vale and to the 100-level barrier for Alibaba and Novartis; concerning ETFs, it is applied to the 10-level barrier for Brazil, Germany, Japan and South Africa and to the 100-level barrier for Russell 1000 and S&P 500.

The results of the mean return equation are shown in Table 9. The mean return after crossing a barrier from below is positive for all the 12 financial assets – and significant at a 5 percent level for all of them except the Russell 1000 ETF. Before crossing a barrier in such movement, the mean is positive for all assets except for the Russell 1000 ETF but only significant at a 5 percent level for five of the assets: the Shell, Vale and Teva ADRs; Brazil and South Africa ETFs. Still concerning the upward movements, the results show that the magnitude of returns is significantly higher after crossing a barrier for all assets, with the exception of the Russell 1000 ETF.

As for the crossings from above, the mean return is negative for all assets after crossing a barrier in such movement – significant at a 5 percent level for all assets but the Novartis ADR, the Russell 1000 and S&P 500 ETFs – and also negative before crossing the barrier for all assets – but only significant at a 5 percent level for seven of them: the Alibaba, Shell, Teva and Vale ADRs and the Brazil, Germany and South Africa ETFs. The magnitude of returns is higher in the 5-day period after crossing a barrier for all assets except for the Russell 1000 and S&P 500 ETFs. Overall, the results presented in Table 10 show no significant differences between the two categories of financial assets.

Table 10 shows the results of the variance equation. In the presence of psychological barriers, we should find positive variance indicators before crossing a barrier – suggesting that the market is more turbulent in this period – and negative indicators after crossing a barrier – indicating that the market is quieter in this period.

Table 9 – Conditional effects test results – Return equation

		C	UB	UA	DB	DA	
ADR	Alibaba	Coef.	0.0983	1.6299	-0.8418	-1.6034	
		p-value	0.1476	0.0017***	0.0000***	0.0170**	
	Nokia	Coef.	-0.0382	0.7351	0.9095	-0.2340	-1.5297
		p-value	0.3395	0.0710*	0.0150**	0.6312	0.0005***
	Novartis	Coef.	0.0354	0.4736	0.7088	-0.2643	-0.4854
		p-value	0.0995*	0.1015	0.0028***	0.3876	0.0736*
	Shell	Coef.	0.0450	0.3777	0.7132	-0.5026	-0.8579
		p-value	0.0929*	0.0000***	0.0000***	0.0000***	0.0000***
	Teva	Coef.	0.0097	0.3458	0.7450	-0.4300	-0.7015
		p-value	0.7643	0.0148**	0.0000***	0.0119**	0.0000***
	Vale	Coef.	-0.0072	0.6160	1.0205	-0.5886	-1.2353
		p-value	0.8868	0.0127**	0.0000***	0.0074***	0.0000***

ETF	Coef.	0.0256	0.3690	0.8655	-0.5792	-1.0529
Brazil	p-value	0.4792	0.0053***	0.0000***	0.0001***	0.0000***
Germany	Coef.	0.0502	0.1783	0.3197	-0.2531	-0.5785
	p-value	0.2540	0.0811*	0.0000***	0.0061***	0.0000***
Japan	Coef.	0.0350	0.1263	0.3577	-0.1362	-0.4280
	p-value	0.0739*	0.1701	0.0000***	0.2949	0.0000***
South Africa	Coef.	0.0281	0.2752	0.6303	-0.2667	-0.9081
	p-value	0.4588	0.0112**	0.0000***	0.0140**	0.0000***
US: Russell 1000	Coef.	0.0673	-0.0848	0.2738	-0.2571	-0.1503
	p-value	0.0000***	0.9112	0.2005	0.3713	0.8607
US: S&P 500	Coef.	0.0581	0.1697	0.2047	-0.1207	-0.0500
	p-value	0.0001***	0.4191	0.0002***	0.6231	0.7796

Table 9 shows the results of the mean equation of a GARCH estimation of the form $R_t = \beta_1 + \beta_2 UB_t + \beta_3 UA_t + \beta_4 DB_t + \beta_5 DA_t + \varepsilon_t$; $\varepsilon_t \sim N(0, V_t)$; $V_t = \alpha_1 + \alpha_2 UB_t + \alpha_3 UA_t + \alpha_4 DB_t + \alpha_5 DA_t + \alpha_6 V_{t-1} + \alpha_7 \varepsilon_{t-1}^2 + \eta_t$. UB, UA, DB and DA are dummy variables. UB takes the value 1 in the 5 days before crossing a barrier from below; UA takes the value 1 in the 5 days after crossing a barrier from below; DB takes the value 1 in the 5 days before crossing a barrier from above; DA takes the value 1 in the 5 days after crossing a barrier from above. Significance at the 10%, 5% and 1% levels are denoted respectively *, ** and ***.

Table 10 – Conditional effects test results – Variance equation

		C	RESID(-1)^2	GARCH(-1)	UB	UA	DB	DA
Alibaba	Coef.	0.7553	0.0478	0.7358	-0.5385	1.0928	-0.9632	1.4206
	p-value	0.0055***	0.0151**	0.0000***	0.0628*	0.2258	0.0000***	0.1180
Nokia	Coef.	0.7941	0.1264	0.7865	-1.0685	-0.9180	1.3644	0.7502
	p-value	0.0000***	0.0000***	0.0000***	0.0271**	0.0118**	0.0131**	0.2654
Novartis	Coef.	0.0226	0.0397	0.9435	0.0741	-0.1783	0.2536	-0.0883
	p-value	0.0000***	0.0000***	0.0000***	0.6242	0.2170	0.1491	0.6097
Shell	Coef.	0.0191	0.0558	0.9301	-0.0643	0.0134	0.3454	-0.1418
	p-value	0.0000***	0.0000***	0.0000***	0.0636*	0.6760	0.0000***	0.0120**
Teva	Coef.	0.0102	0.0149	0.9796	0.1429	-0.1622	1.1689	-1.0615
	p-value	0.0013***	0.0000***	0.0000***	0.0002***	0.0000***	0.0000***	0.0000***
Vale	Coef.	0.0510	0.0498	0.9429	-0.2275	-0.2453	0.4373	0.2057
	p-value	0.0037***	0.0000***	0.0000***	0.1604	0.1044	0.0431**	0.3239

ADR

ETF	Coef.	0.0438	0.0715	0.9088	0.0408	-0.1109	0.3923	0.1985
Brazil	p-value	0.0000***	0.0000***	0.0000***	0.6909	0.2017	0.0002***	0.1374
Germany	Coef.	0.0347	0.0492	0.8869	0.0924	-0.1267	0.1250	0.1274
	p-value	0.0015***	0.0000***	0.0000***	0.0035***	0.0000***	0.0018***	0.0107***
Japan	Coef.	0.0135	0.0918	0.9012	-0.0089	-0.0565	0.1886	-0.0459
	p-value	0.0000***	0.0000***	0.0000***	0.7387	0.0948*	0.0000***	0.2944
South Africa	Coef.	0.0695	0.0821	0.8968	-0.1016	-0.1285	0.1148	0.2549
	p-value	0.0001***	0.0000***	0.0000***	0.1055	0.0288**	0.1286	0.0005***
US: Russell 1000	Coef.	0.0605	0.2516	0.7133	0.7572	-0.1788	0.1784	-0.7377
	p-value	0.0000***	0.0000***	0.0000***	0.4250	0.0000***	0.4187	0.4391
US: S&P 500	Coef.	0.0161	0.1081	0.8764	-0.0501	-0.0477	0.3230	-0.0954
	p-value	0.0000***	0.0000***	0.0000***	0.1595	0.0495**	0.0239**	0.3952

Table 10 shows the results of the variance equation of a GARCH estimation of the form $R_t = \beta_1 + \beta_2 UB_t + \beta_3 UA_t + \beta_4 DB_t + \beta_5 DA_t + \varepsilon_t$; $\varepsilon_t \sim N(0, V_t)$; $V_t = \alpha_1 + \alpha_2 UB_t + \alpha_3 UA_t + \alpha_4 DB_t + \alpha_5 DA_t + \alpha_6 V_{t-1} + \alpha_7 \varepsilon_{t-1}^2 + \eta_t$. UB, UA, DB and DA are dummy variables. UB takes the value 1 in the 5 days before crossing a barrier from below; UA takes the value 1 in the 5 days after crossing a barrier from below; DB takes the value 1 in the 5 days before crossing a barrier from above; DA takes the value 1 in the 5 days after crossing a barrier from above. V_{t-1} refers to the moving average parameter and ε_{t-1}^2 stands for the GARCH parameter. Significance at the 10%, 5% and 1% levels are denoted respectively *, ** and ***.

Regarding upward movements, we find positive variance indicators before crossing a barrier for five of the twelve financial assets (two ADRs and three ETFs) and negative indicators after crossing a barrier for nine assets (four ADRs and five ETFs). As for downward movements, we find positive indicators before crossing barriers for eleven assets (five ADRs and six ETFs) and negative indicators after crossing barriers for six assets (three ADRs and three ETFs).

Finally, Table 11 exhibits the results of the Wald test to the hypotheses listed in Section 3.2.5. We find significant changes in the conditional mean returns after crossing a barrier in an upwards movement for three ADRs and two ETFs (Alibaba, Shell and Teva; Brazil and South Africa), while for downwards movements we observe that changes in the conditional mean returns for two ADRs and three ETFs (Shell and Vale; Brazil, Germany and South Africa). As for differences in the conditional variance, we observe significant results for the Teva ADR and the Germany ETF – concerning upwards movements and regarding downwards movements we find significant differences for three ADRs and one ETF, namely: Alibaba, Shell and Teva; Japan.

Table 11 – Conditional effects test results

		H1	H2	H3	H4	
ADR	Alibaba	Chi-square	1.2574	2.7057	5.8591	
		p-value	0.0047***	0.1000	0.0155**	
	Nokia	Chi-square	0.1073	3.6186	0.0417	0.3461
		p-value	0.7432	0.0571*	0.8381	0.5563
	Novartis	Chi-square	0.5189	0.2791	0.8422	1.1637
		p-value	0.4713	0.5973	0.3588	0.2807
	Shell	Chi-square	7.8901	5.5832	1.5729	20.3956
		p-value	0.0050***	0.0181**	0.2098	0.0000***
	Teva	Chi-square	5.6925	1.3536	17.547	705.7751
		p-value	0.0170**	0.2446	0.0000***	0.0000***
	Vale	Chi-square	1.7849	4.4885	0.0035	0.3152
		p-value	0.1815	0.0341**	0.9530	0.5745

ETF	Brazil	Chi-square p-value	6.9414 0.0084***	5.3912 0.0202**	0.7334 0.3918	0.7552 0.3848
	Germany	Chi-square p-value	1.3130 0.2518	5.7049 0.0169**	15.891 0.0001***	0.0009 0.9758
	Japan	Chi-square p-value	3.7495 0.0528*	3.3155 0.0686*	0.7474 0.3873	9.9656 0.0016***
	South Africa	Chi-square p-value	6.9718 0.0083***	17.115 0.0000***	0.0634 0.8012	1.1055 0.2931
	US: Russell 1000	Chi-square p-value	0.2044 0.6512	0.0141 0.9056	0.9788 0.3225	0.8648 0.3524
	US: S&P 500	Chi-square p-value	0.0259 0.8720	0.0530 0.8180	0.0016 0.9679	2.9682 0.0849*

Table 11 shows the results of a Wald test to four hypotheses. H1: There is no significant difference in the conditional mean return before and after an upwards crossing of a barrier; H2: There is no significant difference in the conditional mean return before and after a downwards crossing of a barrier; H3: There is no significant difference in the conditional variance before and after an upwards crossing of a barrier; H4: There is no significant difference in the conditional variance before and after a downwards crossing of a barrier. Significance at the 10%, 5% and 1% levels are denoted respectively *, ** and ***.

Overall, the evidence suggests that returns and volatility tend to increase after crossing a barrier from below and tend to decrease after crossing a barrier from above which is in line with the equilibrium models that posit a positive relationship between risk and return. The GARCH term is positive and significant at a 1 percent level for every asset, indicating significant GARCH effects. Again, we do not find significant differences between ADRs and ETFs. Finally, analyzing the results of the Wald test, we observe significant signs of the existence of psychological barriers in the Alibaba, Shell, Teva and Vale ADRs, and in the Brazil, Germany, Japan and South Africa ETFs.

5. Conclusion

In this chapter we conducted the first study on psychological barriers in two of the currently most dynamic financial markets, the ADRs and ETFs markets.

We considered a sample of six of the most liquid assets in each of those two markets. Overall, after analyzing the range of each asset's quotes and defining all potential psychological barriers, we found evidence of the existence of psychological barriers in only two of the ETFs under study: Brazil and Germany ETFs. Regarding ADRs, we evidence strong signs of barriers for Vale and inconclusive results for the remaining assets. In spite of that, barrier tests show some indications of psychological barriers for Nokia and Novartis, while the conditional effects test shows stronger signs of barriers for Alibaba, Teva and Shell.

In spite of that evidence, our results are globally consistent with the efficient market paradigm since one of the chief features of an efficient capital market is that prices should not exhibit any particular patterns (Fama, 1970). The signs of psychological barriers evidenced by our results are rather limited, with the majority of the considered assets presenting a behavior typically associated to price efficiency.

Our study presents several limitations which may lead to future research on this topic. For instance: studies with broader samples could lead to stronger results; it could be fruitful to analyze the prevalence of psychological barriers in different time periods according to the price trend prevailing in the market at the time; and it would be interesting to investigate the relationship between the features of ADRs and ETFs (in terms of liquidity, volatility, etc.) and the prevalence of psychological barriers.

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