BREXIT’S EFFECT ON UK ADRs

A STUDY ON ABNORMAL RETURNS SURROUNDING THE BREXIT VOTE

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Abstract:

On June 23rd 2016, the United Kingdom (UK) voted to leave the European Union, resulting in what is often referred to as Brexit. The day after the vote, the British pound (GBP) declined to the lowest level against the US dollar in 30 years and the FTSE 100 lost around GBP 85 billion. This thesis examines how UK firms with American Depositary Receipts (ADR) trading on US stock exchanges are affected by these currency fluctuations in terms of abnormal returns. The results show that UK ADRs experienced significant negative cumulative abnormal returns in the days surrounding the event date. However, when adjusting for the exchange rate, no abnormal returns are observed, suggesting that a perfectly currency hedged firm would not have experienced any abnormal returns. Further, an impact of firm-specific features on abnormal returns is observed. ADRs of firms with relatively larger firm size, financing and operation in the US experience less negative abnormal returns, implying that these firms are better shielded against the currency fluctuations surrounding the Brexit vote.

Keywords:

American Depositary Receipts, Brexit, Abnormal returns, Event study, Difference-in-differences, Currency risk

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1. Introduction

The New York Stock Exchange (NYSE) and NASDAQ are by far the largest equities-based exchanges in the world (WorldAtlas, 2018). Foreign firms looking to raise capital and increase their global trading presence can gain access to these markets through dual-listings. In the United States (US), dual-listings are often conducted through the issuing of American Depositary Receipts (ADR). ADRs are denominated in US dollars (USD) and trade like ordinary stocks, but represent shares of a foreign company trading on a foreign stock exchange. Accordingly, ADRs provide international diversification for US investors, without having to invest directly in a foreign capital market.

Since ADRs are directly related to a foreign firm, they are exposed to foreign currency fluctuations. According to Bin et al. (2004), these fluctuations are in theory supposed to be reflected in the share price of the firm, its operating cash flow and possibly its cost of capital. This will consequently affect the value of the firm's equity. In order to mitigate the currency exposure associated with ADRs, firms can use operational or financial hedges. If the firm is effectively hedged, the influence of currency variations on equity returns is reduced.

This thesis examines the currency fluctuations related to the Brexit vote in the United Kingdom (UK), and how the UK firms with ADRs trading on US stock exchanges are affected in terms of abnormal ADR returns. The announcement can be argued somewhat of an exogenous shock to the market, since the outcome of the vote was unexpected. The day after the announcement, June 24th 2016, the British pound (GBP) declined to the lowest level against the US dollar (USD) in 30 years, and the FTSE 100 experienced a loss of roughly GBP 85 billion. By incorporating a standard event study methodology with two variations of the market model, this thesis examines the impact of the exchange rate on abnormal returns. To obtain more robust results, the abnormal returns are further examined using a difference-in-differences analysis. In addition, a cross-sectional analysis is conducted to observe if any firm-specific factors may contribute to a more effective hedge.

The obtained empirical results show that (1) the announcement day of the Brexit was accompanied by significantly negative abnormal returns for UK ADRs. However, when adjusting for the exchange rate, these returns became insignificant. (2) Firm-specific features affect the cumulative abnormal returns. A relatively larger operating and financing fraction in the US, and firm size implies that the ADR experienced smaller value losses in conjunction with the Brexit announcement.

1.1 Background

1.1.1 American Depositary Receipts

An ADR is an instrument traded on US markets that is issued by a non-US firm. The share price is denominated in US dollars and the shares are settled through the US system, which facilitates for American investors to attain an international equity exposure. In 2016 – the year of Brexit –a total of 152.1 billion depositary receipts traded in the US markets at a value of approximately USD 2.9 trillion (BNY Mellon, 2017).

Benefits associated with ADR investments are discussed by for an instance Gande (1997). The author argues that ADR investments enable pension funds and banks who are prohibited from holding foreign securities to diversify internationally. As a consequence of extensive reporting required by the US Securities and Exchange Commission, ADR trading may also support shareholder communication. Moreover, ADRs can reduce the costs associated with direct foreign investments, such as double commissions, costs related to dividends denominated in foreign currency and safekeeping fees abroad. However, since ADRs are based on the underlying foreign share, they contain a degree of exchange rate risk. Although they are denominated in dollars, the foreign currency value is reflected in the price.

ADRs are either sponsored or unsponsored. Sponsored ADRs constitute the majority of ADRs. A sponsored ADR is issued with the involvement of the firm, to establish trading presence and raise capital. ADRs are additionally categorised as either level I, II or III, depending on the level of regulatory requirements the ADR is subject to.

1.1.2 Brexit

On June 23rd 2016, a vote was held in the UK to determine if the country should leave or remain in the European Union (EU). The outcome of the voting was unexpected with

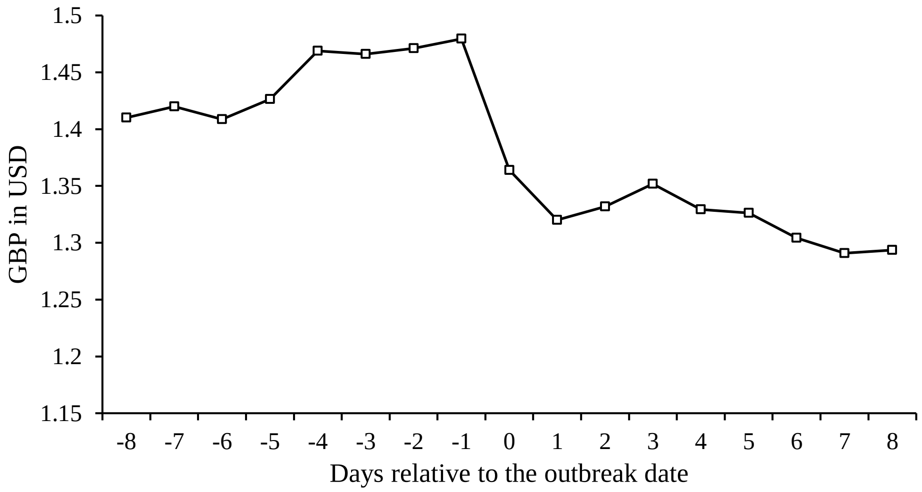
51.9 percent voting to leave, resulting in what is commonly referred to as Brexit. (The Electoral Commission, 2016).

In March 2017, the UK initiated the two-year exit process by invoking Article 50 of the Lisbon Treaty. Over two years have now passed, but a withdrawal agreement is yet to be reached. The withdrawal agreements presented to UK members of parliament have all been rejected and until present day the outcome of Brexit is highly uncertain.

Brexit has significantly affected financial markets and the British pound. The day after the vote, on June 24th 2016, the GBP fell 8 percent, reaching the lowest level against the USD in 30 years. Moreover, the FTSE 100 index lost approximately GBP 85 billion. The effect of the initial vote was not only visible in the UK. Financial markets worldwide, including the US, France and Germany experienced significant losses in value as a consequence of the increased political uncertainty (Kharpal and Barnato, 2016).

Figure I: Exchange rate development (GBP/USD)

The graph shows the closing GBP/USD exchange rate on the days surrounding the event date [-8,+8]. Day 0 equals June 24th 2016, the date after the vote. The data is collected from Capital IQ.



2. Previous literature and research question

Specific events and their impact on asset pricing have inspired numerous ADR studies. The studies often use an event study methodology to examine the period prior to, during and after the announcement in order to observe plausible abnormal performance in conjunction with the event.

Callaghan, Kleiman and Sahu (1999) examine the stock performance of ADRs after an initial public offering (IPO) or a seasoned equity offering (SEO) in the time period 1986-1993. They find evidence that IPOs and SEOs of ADRs yield considerable positive abnormal returns both in early trading and in the long-run. The authors apply an abnormal returns methodology, which is commonly used and further noticeable in for an instance Foerster and Karolyi's (2000) research on the long-run equity return performance of non-US firms that raise capital in US markets.

Furthermore, a large part of the literature on ADRs involves the exchange rate exposure. The unanticipated shifts in exchange rates are in theory supposed to be reflected in the translated share price, cost of capital and operating cash flows. This should consequently be reflected in the equity returns of the firm. De Santis and Gerard (1998) find evidence that the premium for taking on exchange rate risk often constitute a vital fraction of the total premium, with the exception of US equity markets.

Bailey et al. (2000), and Huang and Stoll (2001) study the impact of currency exposure on ADR pricing. By observing the British sterling devaluation in 1992 and the Mexican peso devaluation in 1994, they investigate how currency crises affect the market liquidity of a company's ADR shares. Huang and Stoll (2001) show that the currency volatility related to the crises generate little or no effect on the market liquidity of the ADRs in the US market, thus providing no support for a linkage between exchange rate fluctuation and firm value. By studying the peso crisis' effect on Latin American ADR price performance and trading volumes, Bailey et al. (2000) find that the peso crisis had no significant impact on the trading patterns for non-Mexican securities.

Currency crises are further examined in Bin et al. (2004) who study six different currency crises and the impact on the corresponding ADR performance. The authors investigate if any significant market-adjusted returns are observable in connection with the outburst of a crisis and if firm characteristics influence these returns. The study present results of significant negative abnormal returns for the selected ADR portfolios related to the crises. Furthermore, the study indicates that firms of a relatively larger size, market liquidity and fraction of activities in the US are better hedged against currency crises.

As the announcement of Brexit is a relatively recent event, previous literature on the effect of Brexit on ADRs is limited. Schaub (2017) investigates the short-term impact of Brexit on UK ADRs on NYSE and finds that UK ADRs lost over 10 percent of their value the day after the vote results were presented with an additional loss of 5 percent the following day, larger than the losses experienced by the S&P 500 and FTSE 100 indices. The results further suggest that ADR price performance may impact the exchange rate, in addition to the impact of the exchange rate fluctuations on the ADR returns.

This thesis aims to contribute to research by examining the impact of exchange rate fluctuations on ADR price performance with the announcement of Brexit as the chosen event. In addition to examining if any significant abnormal returns are observable in conjunction with the announcement, this study investigates if US investors are protected from value losses if the firm that issued the ADR is effectively hedged against currency exposure. Moreover, firm-specific features are analysed in order to observe if any of such features have an impact on the possible abnormal returns. The research questions related to this study can be formulated as:

- *Do ADRs issued by UK firms on average earn a risk-adjusted abnormal return in conjunction with Brexit in short term?*
- *If so, is the return associated to any firm-specific features?*

3. Methodology

This thesis will employ an event study methodology to study plausible abnormal performance related to the Brexit vote. The performance of UK ADRs is examined prior to and after the announcement of the vote results. A potential bias when comparing the same group over time is that the observed outcome could be the result of trends. To reduce this bias and strengthen the robustness of the findings, a separate difference-in-differences analysis is conducted.

3.1 Event study methodology

The event study methodology is a well-established tool to examine the effect of a specific event on security market behaviour. In this thesis, the structure given in Campbell et al. (1997) is followed.

3.1.1 Definition of the event of interest

The event of interest in this thesis is the Brexit vote taking place on June 23rd 2016. The result was unanticipated, consequently resulting in what could be argued an exogenous shock. Since the result of the vote was presented late on June 23rd 2016, the market reacted the following trading day, i.e. June 24th 2016. As the market reaction is what this thesis aims to study, June 24th 2016 is selected as the event day (day “0”).

3.1.2 Definition of the estimation and event windows

Figure II describe the chosen estimation and event period. The chosen estimation period used to predict the normal performance is defined as L1=(T1-T0)=126 trading days. Moreover, two event windows which include the event day are observed. The first event period is defined as L2= (T3-T2) = 3 trading days and the second L3= (T3-T2) = 9 trading days. The number of days in the event window should be evaluated on the basis of the event of interest, and may thus vary between event studies. To assure that the political information has been integrated in the stock price, our second event window L3 is defined as 9 trading days, in accordance with the argument presented in Dangol (2008).

The estimation window L1 is equal to 126 trading days. In accordance with Benninga (2008), 126 observations in the estimation window is necessary to obtain the relationship between the stock returns and the market returns.

Figure II: Event and estimation windows

The figure presents the selected estimation window of 126 days and the two event windows covering day [-1,+1] and [-4,+4].

	Estimation window		*Event window*	
	L_1		L_2	
	T_0 — T_1	T_2	0	T_3
Event window [-1,+1]	126 days		1 day	1 day
Event window [-4,+4]	126 days		4 days	4 days
	T_0 — T_1	T_2	0	T_3
	L_1		L_3	
	Estimation window		*Event window*	

3.1.3 Determination of selection criteria

The sample consists of 23 sponsored UK ADRs trading on the NYSE or NASDAQ. The sample is described in detail in section 4.1.

3.1.4 Definition of normal performance

The normal stock performance is defined as the performance of the stock if the event would not have occurred. In order to obtain the abnormal return for stock *i* on day *t* we calculate the difference between the observed and the predicted return:

$$AR_{i,t} = R_{i,t} - E(R_{i,t}|X_t) \qquad (1)$$

where $AR_{i,t}$, $R_{i,t}$, and $E(R_{i,t}|X_t)$ are the abnormal, actual and normal performance respectively for stock *i* in time period *t*. The market model is employed to estimate the predicted normal performance of stock *i*. The model, which is commonly used assumes a stable linear relation between the return of stock *i* and the market return. The normal performance in accordance with the market model can be stated as:

$$\widehat{R}_{i,t} = \widehat{\alpha}_i + \widehat{\beta}_i R_{MKT,t} \qquad (2)$$

Where $\widehat{R}_{i,t}$ and $R_{MKT,t}$ are the individual firm's stock return and the selected market return on day *t*, and $\widehat{\alpha}_i$ and $\widehat{\beta}_i$ are the coefficients obtained from robust regression over the estimation window. Robust standard errors are used to adjust for plausible heteroscedasticity.

However, in the case of ADRs, it is more appropriate to use a variation of the market model. An estimation of the normal performance coherent with the market model only based on the US market return may be insufficient for predicting the ADRs' normal return since the ADR is associated with the underlying stock trading in the home country market. To adjust for this, the corresponding UK market return and the exchange rate are added as independent variables for the pricing of ADRs, as they are found the most significant parameters in pricing an ADR according to Kim et al. (2000):

$$\widehat{R}_{i,t} = \widehat{\alpha}_i + \widehat{\beta_1} R_{US,t} + \widehat{\beta_2} R_{UK,t} + \widehat{\beta_3} R_{FX,t} + \varepsilon_{i,t} \quad (3)$$

Where $R_{UK,t}$ and $R_{FX,t}$ are the home country market return and the exchange rate return on day t respectively.

Furthermore, an additional regression is run:

$$\widehat{R}_{i,t} = \widehat{\alpha}_i + \widehat{\beta_1} R_{US,t} + \widehat{\beta_2} R_{UK,t} + \varepsilon_{i,t} \quad (4)$$

By running the Eq. (3) and (4) regressions, the impact of an effective currency hedge on abnormal returns is examined. By adjusting for exchange rate fluctuations in Eq. (3), an assumption of that UK ADR firms are effectively hedged is integrated in the calculation of the normal performance.

3.1.5 Calculation of abnormal returns and cumulative abnormal returns

Abnormal returns are calculated using Eq. (1), where the normal performance is estimated using Eq. (3) and (4) respectively. The average mean abnormal return (AAR) across the ADRs on day t is:

$$AAR_t = \frac{1}{N} \sum_{i=1}^{N} AR_{i,t} \quad (5)$$

In order to facilitate the identification of unique return patterns in conjunction with the Brexit vote, the average abnormal returns are summed over the time intervals T2 to T3 of the event windows. The cumulative average abnormal return for the time interval T2 to T3 is formulated as:

$$CAAR_{T2,T3} = \sum_{T2}^{T3} AAR_t \quad (6)$$

To test whether the average abnormal return and the cumulative average abnormal return are significantly different from zero, a two-sided t-test is employed as suggested by Brown and Warner (1985) among others.

3.1.6 Cross-sectional analysis

In order to identify plausible determinants of the variation in the cumulative abnormal return, a cross-sectional regression is exercised. Proxies for firm size, financing and operating fraction in the US are included as independent variables for the dependent variable CAR. The choice of independent variables are coherent with the variables used by Bin et al. (2004).

Table I: Variables in the cross-sectional regression

The table presents a summary of variables used in the cross-sectional regression. The data used to compute the variables is collected from Capital IQ and annual reports.

Notation	Variable	Definition
CAR_i	Dependent variable	The cumulative abnormal return for each individual firm in the sample. Computed as the sum of the abnormal return in the specific event window
$MKTCAP_i$	Independent variable	The natural logarithm of the individual firm's market capitalisation in USD millions as of the 31 December 2015
$USFF_i$	Independent variable	The ADR-capitalisation-to-total-capitalisation ratio used as a proxy for the firm's financing fraction in the US as of the 31 December 2015
$USOF_i$	Independent variable	The US-sales-to-total-sales ratio used as a proxy for the firm's operation fraction in the US as of the 31 December 2015

The following regression is used:

$$\mathrm{CAR_i} = \beta_{0i} + \beta_{1i}\mathrm{MKTCAP_i} + \beta_{2i}\mathrm{USFF_i} + \beta_{3i}\mathrm{USOF_i} + \varepsilon_{i,t} \qquad (7)$$

where $\mathrm{MKTCAP_i}$ is the natural logarithm of the market capitalisation measured in USD millions as a proxy for the firm size, $\mathrm{USFF_i}$ is the ADR-capitalisation-to-total-capitalisation ratio as a proxy for the firm's financing fraction in the US and $\mathrm{USOF_i}$ is the US-sales-to-total-sales ratio as a proxy for the firms' operating fraction in the US. For the $\mathrm{USOF_i}$ proxy to be an efficient measure of the operation proportion in the US, it is necessary that the US sales are in USD to have an impact on the currency exposure. As it is not possible to confirm due to limited information, this is assumed in this thesis.

3.2 Difference-in-differences

As a complement to the event study methodology, a difference-in-differences analysis is conducted. The difference-in-differences methodology is a tool used to estimate the effect of an event, comparing the pre- and post-event differences in the outcome of a treatment and a control group (Ashenfelter and Card 1985). In this thesis the effect of the Brexit referendum on UK ADRs is examined by comparing the changes in abnormal returns over time between UK and non-UK ADRs.

Abnormal returns are calculated using Eq. (2), where S&P 500 is used as a proxy for the market return. Since the control group consists of non-UK ADRs, it is reasonable to calculate predicted normal performance based on their common market, i.e. the US market.

3.2.1 Difference-in-differences regression

The effect of the Brexit referendum on ADRs' abnormal return is estimated using the following robust regression:

$$AR_{i,t} = \beta_0 + \beta_1 time + \beta_2 treatment + \beta_3 time * treatment + \varepsilon_i \qquad (8)$$

where the first and the second variables are dummy variables. The time variable takes on the value one if the date is after the Brexit vote, while the treatment variable takes on the value one if the observation is part of the treatment group. The two terms are then multiplied to calculate the third term which is the difference-in-differences estimator. This estimator expresses whether the estimated mean change in abnormal returns pre and post the event is different for the two groups.

Table II: Variables in the difference-in-differences regression

The table presents a summary of variables used in the difference-in-differences regression. The dependent variable $AR_{i,t}$ is computed using the market model with the US index S&P 500 as a proxy for the market.

Notation	Variable	Definition
$AR_{i,t}$	Dependent variable	The abnormal return for each individual firm *i* on day *t*. Computed as the difference between the actual return and the predicted normal return
Time	Independent variable	A dummy variable taking on the value one for the dates post June 24th 2016, when the Brexit vote outcome was announced, and zero otherwise
Treatment	Independent variable	A dummy variable taking on the value one if an observation is within the treatment group and zero otherwise
Time*Treatment	Independent variable	An interaction of the time and treatment variables is used as the difference-in-differences estimator. It is equal to one if the date is post June 24th 2016 and the observation is within the treatment group, and zero otherwise

3.2.2 Control group

The difference-in-differences analysis requires a control group which is assumed to be unaffected by the event. There are several methodologies that can be used to find a control group, but matching is commonly used as it mitigates selection bias. In this thesis the propensity score matching methodology is used to assign the control group. Propensity score matching is one of the more popular matching techniques initially introduced by Rosenbaum and Rubin (1983).The basic steps in propensity score matching described by Stuart (2010) are followed.

First, a propensity score is estimated based on the observable characteristics of the firm, in this case the 5-year beta, price-to-book ratio and market capitalisation. The propensity score is estimated using a logistic regression, in which the treatment variable is the dependent variable. This is done for all firms in the treatment group, but also for all non-UK sponsored level II and III ADRs.

Observations from the treatment group are matched with non-UK ADRs based on their propensity score. This process is performed using the nearest neighbour methodology, which is one of the most common methods used for matching (Stuart, 2010). This thesis employs the nearest neighbour methodology without replacement, so that once a non-UK ADR is matched with a firm in the treatment group, it cannot be matched again.

Three of the firms in our treatment group lack a non-UK counterpart with a similar propensity score and are thus dropped, resulting in a treatment and control group of 20 ADRs respectively.

Finally, the quality of the match is evaluated by comparing the means, using a t-test for the hypothesis that the means of the two groups are equal. The results show that hypothesis cannot be rejected, implying a solid match (see appendix III).

4. Data

4.1 Event study

The sample consists of UK ADRs listed on US exchange markets (NYSE and NASDAQ) at the time of Brexit. The sample is collected from JP Morgan's website *www.adr.com*, which lists all ADRs trading between the years of 1997 and 2019. An initial sample of 32 UK ADRs is collected from the website. From this list, only sponsored level II and III ADRs are chosen, resulting in 23 ADRs. Sponsored level I and unsponsored ADRs are excluded as they trade OTC. Stocks that trade OTC have less trade liquidity which may reduce or delay the effect of an unexpected event like the Brexit vote (Ang et al., 2013).

As a next step in sorting the sample, only firms which have data available for the entire estimation window, i.e. 131 trading days before the event day, are selected. For simplicity, only days when markets are open in both the UK and the US are included as trading days. Since none of the chosen firms lack data for longer periods than a few days, all 23 firms are kept. The mentioned missing values are due to lack of trading activity on single days for some of the more thinly traded ADRs and are adjusted by using the latest closing price. This is one of the commonly used methods for treating missing values recommended by Bartholdy et al. (2006). A table of the selected companies is found in appendix I.

The normal return of the ADRs are calculated using both a US and a UK index. S&P 500, which is a common benchmark index for stock-market performance, is used as the US index. FTSE 100 is used as the UK counterpart. Since neither index is adjusted for dividends, the ADR returns are computed including dividends for consistency.

Daily closing prices, exchange rates and market indices are collected from Capital IQ. Table III presents the daily return of the selected ADRs, S&P 500, FTSE 100 and GBP/USD for the days in the event windows. The year prior to Brexit, i.e. 2015, is used as the base year when computing the independent variables in the cross-sectional analysis.

Table III: Descriptive statistics

Summary statistics of the UK ADRs, the US and UK indices, and the GBP/USD exchange rate in the days surrounding the event date June 24th 2016 and over the selected event windows. The S&P 500 constitutes the US index, while FTSE 100 is used as the UK index. The portfolio of UK ADRs consists of 23 sample firms.

Day	Portfolio	Mean	SD	Min	Max
– 4	UK ADRs	3.450%	2.451%	-3.952%	8.136%
– 4	US index	0.581%	-	0.581%	0.581%
– 4	UK index	3.038%	-	3.038%	3.038%
– 4	UK pound	2.973%	-	2.973%	2.973%
– 3	UK ADRs	1.163%	1.014%	-1.120%	3.408%
– 3	US index	0.271%	-	0.271%	0.271%
– 3	UK index	0.363%	-	0.363%	0.363%
– 3	UK pound	-0.191%	-	-0.191%	-0.191%
– 2	UK ADRs	0.413%	0.831%	-2.266%	2.388%
– 2	US index	-0.165%	-	-0.165%	-0.165%
– 2	UK index	0.556%	-	0.556%	0.556%
– 2	UK pound	0.347%	-	0.347%	0.347%
– 1	UK ADRs	2.286%	1.064%	0.232%	4.388%
– 1	US index	1.336%	-	1.336%	1.336%
– 1	UK index	1.228%	-	1.228%	1.228%
– 1	UK pound	0.565%	-	0.565%	0.565%
0	UK ADRs	-9.285%	6.615%	-27.503%	-1.839%
0	US index	-3.592%	-	-3.592%	-3.592%
0	UK index	-3.146%	-	-3.146%	-3.146%
0	UK pound	-7.801%	-	-7.801%	-7.801%
1	UK ADRs	-5.430%	5.429%	-20.922%	0.323%
1	US index	-1.810%	-	-1.810%	-1.810%
1	UK index	-2.549%	-	-2.549%	-2.549%
1	UK pound	-3.233%	-	-3.233%	-3.233%
2	UK ADRs	3.517%	1.908%	1.038%	10.432%
2	US index	1.777%	-	1.777%	1.777%
2	UK index	2.644%	-	2.644%	2.644%
2	UK pound	0.910%	-	0.910%	0.910%
3	UK ADRs	2.555%	1.314%	-0.977%	4.663%
3	US index	1.703%	-	1.703%	1.703%
3	UK index	3.577%	-	3.577%	3.577%
3	UK pound	1.494%	-	1.494%	1.494%
4	UK ADRs	1.002%	2.271%	-4.472%	4.508%
4	US index	1.356%	-	1.356%	1.356%
4	UK index	2.268%	-	2.268%	2.268%
4	UK pound	-1.658%	-	-1.658%	-1.658%
[-1,+1]	UK ADRs	-4.143%	6.895%	-27.503%	4.388%
[-1,+1]	US index	-1.355%	2.053%	-3.592%	1.336%
[-1,+1]	UK index	-1.489%	1.951%	-3.146%	1.228%
[-1,+1]	UK pound	-3.489%	3.445%	-7.801%	0.565%
[-4,+4]	UK ADRs	-0.037%	5.207%	-27.503%	10.432%
[-4,+4]	US index	0.162%	1.706%	-3.592%	1.777%
[-4,+4]	UK index	0.887%	2.252%	-3.146%	3.577%
[-4,+4]	UK pound	-0.733%	3.018%	-7.801%	2.973%

Market capitalisation, ordinary shares outstanding and trading volume are collected for the end of the base year from Capital IQ. Further, sales data and ADRs outstanding for the base year are collected from annual reports.

4.2 Difference-in-differences

A large sample of non-UK ADRs is required to find a suitable match for the treated UK ADRs. A list of all non-UK sponsored level II and III ADRs are therefore collected from JP Morgan's website *www.adr.com*. For the UK and non-UK ADRs, individual betas, market capitalisation and price-to-book ratio are obtained from Capital IQ. To facilitate the data collection, daily market data for the 20 selected companies is collected from Capital IQ after the matching. This data is used to calculate the abnormal returns in the difference-in-differences analysis. A table over the final control group is found in appendix III.

5. Hypotheses formation

5.1 Abnormal returns hypothesis

The abnormal returns hypothesis is formulated in order to test if any statistically significant abnormal returns are observed in connection with the Brexit vote.

H_0: In the event of the unexpected outcome of the Brexit vote, a statistically significant abnormal return should not be observed for UK ADRs.
H_1: In the event of the unexpected outcome of the Brexit vote, a statistically significant abnormal return should be observed for UK ADRs.

The hypothesis is tested by conducting an event study and an additional difference-in-differences analysis as explained in Section 3. The difference-in-differences analysis is conducted as a complement to the event study in order to observe if the obtained results are biased from trends. By integrating both methods, the robustness of the results is increased. As a consequence of high currency volatility in conjunction with the event date, abnormal returns are expected to be observed due to the currency risk incorporated in the UK ADR price.

5.2 Currency hedging hypothesis

An additional hypothesis is included to examine the impact of an effective currency hedge on abnormal returns. As UK ADRs are associated with both the US and UK market, it is of interest to investigate how exposed the UK ADRs are to fluctuations in the GBP/USD exchange rate. Incorporating the exchange rate variations in the predicted normal performance, the ADR abnormal returns surrounding the Brexit vote are tested under the assumption that the UK firms are effectively hedged.

H_0: In the event of the unexpected outcome of the Brexit vote, a statistically significant ADR abnormal return should not be observed for effectively currency hedged UK firms.

H_1: In the event of the unexpected outcome of the Brexit vote, a statistically significant abnormal return should be observe for effectively currency UK firms.

Since the GBP fluctuations related to the Brexit vote are substantial, no significant abnormal returns are expected to be found when adjusting for the exchange rate.

5.3 Firm-specific characteristics hypothesis

As an additional analysis, a third hypothesis is formulated to provide further explanation of the abnormal returns and the aspects affecting them.

H_0: All other things equal, the ADR-issuing firm's market capitalisation, financing fraction and/or operating fraction within the US do not have an impact on plausible market value losses in conjunction with the Brexit vote.
H_1: All other things equal, if an ADR-issuing firm has a relatively larger market capitalisation, a greater financing fraction and/or a greater operating fraction within the US, they do experience a lesser market value loss in conjunction with the Brexit vote.

The hypothesis is based on the belief that a larger amount of US sales and US financing imply a lower GBP currency exposure and thus should result in a smaller market value loss. Under the assumption that US sales are denominated in USD, the US revenue streams should positively affect the UK firm as it should imply that they are less exposed to the currency fluctuations. In line with this reasoning, the US financing fraction should positively affect the UK firm as it is denominated in USD. Moreover, larger firms are believed more likely to minimize their currency exposure through hedging. The hypothesis is tested by using a one-sided t-test.

4. Empirical results

4.1 Event study outcomes

Table IV: Abnormal return and cumulative abnormal return

The table shows the average abnormal return (AAR) and the average cumulative abnormal return (CAAR) for the sample of 23 UK ADRs for each day in the event window. The predicted normal return used to calculate the AR is computed using a variation of the market model, including both the UK index FTSE 100 and the US index S&P 500:

$$\hat{R}_{i,t} = \hat{\alpha}_i + \widehat{\beta_1} R_{US,t} + \widehat{\beta_2} R_{HC,t} + \varepsilon_{i,t}$$

CAAR is the sum of the previous days AAR. The significance of the results are tested using a two-sided t-test.

	UK ADRs	
Days relative to the outbreak date	AAR (%)	CAAR (%)
-4	2.090***	2.090***
-3	0.882***	2.972***
-2	0.470***	3.442***
-1	0.783***	4.225***
0	-5.020***	-0.795
1	-2.960***	-3.755**
2	1.190***	-2.565
3	0.018	-2.547
4	-0.830	-3.377
[-1,+1]		-7.197***
[-4,+4]		-3.377***

*Denotes a significance level of 10%

**Denotes a significance level of 5%

***Denotes a significance level of 1%

Table IV presents the obtained single-day average abnormal returns and the multiday average cumulative abnormal returns for UK ADRs over the event period surrounding the Brexit vote. The estimates are the result of an OLS regression including the calculation of the predicted normal return from Eq. (4), where the GBP exchange rate fluctuations are left out.

The UK ADRs a show significant negative average cumulative abnormal return of -7.197 percent and -3.377 percent over the two selected event windows [-1, +1] and [-4, +4] respectively. The average abnormal return for the event date ("day 0") is statistically significant at -5.020 percent, followed by an additional day of negative abnormal return at -2.960 percent (significant at the 5 percent level).

Of interest is the significant positive abnormal returns in the days prior to the announcement of the Brexit vote results. The average cumulative abnormal return for day -1 is positively significant at 4.225 percent. A plausible explanation for the positive returns, except for firm-specific factors, could be media's anticipation that the UK would vote to stay in the EU.

Summarized, these results suggest that UK ADRs suffer significant negative cumulative abnormal returns in connection with the Brexit vote when the exchange rate fluctuations are not accounted for in the model.

Table V: Currency adjusted abnormal return and cumulative abnormal return

The table shows the average abnormal return (AAR) and the average cumulative abnormal return (CAAR) for the sample of 23 ADRs for each day in the event window. The predicted normal return used to calculate the AR is computed using a variation of the market model, including the UK index FTSE 100, the US index S&P 500 and the GBP/USD exchange rate:

$$\hat{R}_{i,t} = \hat{\alpha}_i + \widehat{\beta_1} R_{US,t} + \widehat{\beta_2} R_{HC,t} + \widehat{\beta_3} R_{FX,t} + \varepsilon_{i,t}$$

CAAR is the sum of the previous days AAR. The significance of the results are tested using a two-sided t-test.

	UK ADRs	
Days relative to the outbreak date	AAR (%)	CAAR (%)
-4	0.101	0.101
-3	0.992***	1.093**
-2	0.203	1.296**
-1	0.428**	1.724**
0	0.060	1.784**
1	-0.894	0.890
2	0.634	1.524
3	-0.928**	0. 596
4	0.328	0.924
[-1,+1]		-0.406
[-4,+4]		0.924

*Denotes a significance level of 10%

**Denotes a significance level of 5%

***Denotes a significance level of 1%

Next, we adjust the model for fluctuations in the exchange rate. The results are presented in Table V. Noticeable is that when the exchange rate is accounted for, the observed average abnormal returns in the period surrounding the Brexit vote are less negative and seldom significant. On the day before the event date ("day -1"), a significantly positive average abnormal return of 0.428 percent is observed (at the 5 percent level). Moreover, the only significant average abnormal returns in the period are positive and before the announcement date. On the event date ("day 0"), an insignificant positive average abnormal return of 0.060 percent is observed, implying that the significant negative average abnormal return observable in Table IV for the same day is due to the exchange rate fluctuations. The two selected event windows [-1, +1] and [-4, +4] show insignificant average cumulative abnormal returns of -0.406 and 0.924 percent respectively.

In comparison with Table IV, Table V provides results that suggest that fluctuations in the GBP exchange rate have explained a substantial proportion of the average abnormal returns, large enough to eliminate the significant negative average cumulative abnormal return over the event windows.

4.2 Determinants of abnormal performance

Table VI present the results from the cross-sectional regression, where the average cumulative abnormal return for each individual UK ADR firm is explained by proxy measures of firm size, financing fraction in the US and operating fraction in the US:

$$CAR_i = \beta_{0i} + \beta_{1i}MKTCAP_i + \beta_{2i}USFF_i + \beta_{3i}USOF_i + \varepsilon_{i,t}$$

The table present various significant findings. The average cumulative abnormal returns for the selected event windows are positively related to the firm's size, measured in terms of market capitalisation. Thus, UK firms with a large market capitalisation compared to other firms in the sample experience a smaller decline in market value in connection with the Brexit vote. A plausible explanation is that larger firms are more likely to use financial and operational hedging tools, thus minimizing their currency exposure. However, these findings are inconsistent with the findings from examining the cumulative abnormal returns adjusted for the exchange rate. Although still positively related, the impact of the firm size on the cumulative return is in this case insignificant for both selected event windows. This suggests that if a firm is effectively hedged against currency exposure, the size of the firm does not affect the abnormal return.

Moreover, the US financing and operating fraction are significantly positively related to average cumulative abnormal returns for both selected event windows and normal return predictions. This indicates that firms with a relatively larger US financing and operating fraction yielded a less negative cumulative abnormal return as a response to the Brexit vote. The results suggests that the firms with a larger financing and operating fraction in the US are on average better hedged against currency exposure risk. The results are consistent with previous finding by Bin et al. (2004).

Table VI: Determinants of abnormal performance

The table show the regression results for the cross-sectional analysis using the model:

$$CAR_i = \beta_{0i} + \beta_{1i}MKTCAP_i + \beta_{2i}USFF_i + \beta_{3i}USOF_i + \varepsilon_{i,t}$$

The table contains the results for the cumulative abnormal return over the event windows. CAR_i is computed using two variations of the market model. The regression results shown in panel A uses the US and UK market index to predict normal return. The predicted normal return for CAR_i in Panel B is additionally adjusted for currency. The natural logarithm of market capitalisation is used as a proxy for firm size (MKTCAP), the ADR-capitalisation-to-total-capitalisation ratio is used as a proxy for US financing fraction (USFF) and US-sales-to-total-sales ratio are used as the proxy for the US operating fraction (USOF) for each individual firm. The significance of the results are tested using a one-sided t-test.

Performance	β_0	β_1	β_2	β_3
(A) Cumulative abnormal return				
CAR [-1,+1]	-0.584	0.036**	0.430***	0.276***
t statistic	(-3.348)	(2.391)	(3.295)	(4.344)
CAR [-4,+4]	-0.424	0.025***	0.572***	0.255***
t statistic	(-3.849)	(2.623)	(6.947)	(6.350)
(B) Cumulative abnormal return adjusted for GBP exchange rate				
CAR [-1,+1]	-0.171	0.008	0.472***	0.147**
t statistic	(-0.960)	(0.500)	(3.543)	(2.263)
CAR [-4,+4]	-0.162	0.007	0.599***	0.173***
t statistic	(-1.528)	(0.764)	(7.547)	(4.473)

*Denotes a significance level of 10%

**Denotes a significance level of 5%

***Denotes a significance level of 1%

4.3 Difference-in-differences outcome

Table VII: Difference-in-differences analysis

The table shows the difference-in-differences regression for event window 2, [-4,+4] using:

$$AR_{i,t} = \beta_0 + \beta_1 \text{time} + \beta_2 \text{treatment} + \beta_3 \text{time} * \text{treatment} + \varepsilon$$

The dependent variable AR is computed using the market model with the US index S&P 500 as a proxy for the market. The independent variables used are dummy variables. The time variable takes on the value one if the date is after the event date and treatment takes on the value one for the observations in the treatment group. The interaction time*treatment is the difference-in-differences estimator which takes on the values one for observations in the treatment group on days after the Brexit vote. Robust standard errors are used to correct for potential heteroscedasticity.

Performance	β_0	β_1	β_2	β_3
AR [-4,+4]	0.003***	-0.004**	0.009***	-0.022***
t statistic	(2.926)	(-2.009)	(4.293)	(-4.147)

*Denotes a significance level of 10%

**Denotes a significance level of 5%

***Denotes a significance level of 1%

In the difference-in-differences analysis, UK ADRs average abnormal return is compared to the average abnormal return of the selected control group. The difference-in-differences estimator is estimated via the time*treatment coefficient. For the event window [-4,+4], Table VII presents a significantly negative difference-in-differences estimator is observable. This indicates that the average abnormal return of the UK ADRs over the event window are significantly negative when adjusting for the average abnormal return of the control group. The daily difference in average abnormal return between the treatment and control group is illustrated in appendix IV.

The treatment variable is statistically significant and positive, implying that the overall average abnormal return for UK ADRs is relatively more positive than the return of the control group. The time variable further implies that the announcement of Brexit resulted in a statistically significant negative average abnormal return at the 5 percent level for both the treatment and control group.

Summarized, the difference-in-differences analysis shows that the average abnormal returns experienced by UK ADRs in connection with the Brexit announcement are negative and statistically significant even after subtracting the behaviour of the control group that is not affected by the exchange rate fluctuations related to the announcement.

5. Conclusion

This thesis investigates the effect of the Brexit vote on UK ADRs by observing abnormal returns. The abnormal returns are computed using a standard event study methodology incorporating a t-test for significance testing of the *abnormal returns hypothesis.* As a complement to the event study methodology, a difference-in-differences analysis is employed to adjust for a potential trend-related bias for a more robust result.

The results show that UK ADRs experienced a significant negative average cumulative abnormal return in the two selected event windows surrounding the event date. Moreover, the difference-in-differences estimator obtained show that the estimated mean change in abnormal return before and after the event is statistically different at the 1 percent level over the event window [-4+4]. The results thus reject the null hypothesis that no abnormal returns should be observed in conjunction with the Brexit vote.

The ADRs exposure to currency risk is tested through the *currency hedging hypothesis*. When adjusting the abnormal returns for the exchange rate, no significant results are found. This suggest that the exchange rate is a main contributor to the negative abnormal returns. Accordingly, the result implies that if the firm is effectively hedged against currency fluctuations, it should not experience any abnormal returns.

Furthermore, the determinants of the abnormal performance are tested via a cross-sectional analysis. The findings show that the individual firm's cumulative abnormal return is significantly positively related to its financing and operating fraction in the US, and firm size. This implies that firms with a relatively larger financing and operating fraction in the US, and firm size in terms of market capitalisation are better hedged against currency exposure risk.

The proxies used in the cross-sectional analysis are subject to improvements. The proxy for the financing fraction in the US does not take capital structure into account, which can affect the efficiency of the measure and thus the results. By including the plausible fraction of debt denominated in GBP, the measure may be improved. In the case of a currency depreciation, the GBP denominated debt should decrease in value and thus affect the abnormal returns positively. As for the proxy of operating fraction in the US, it only considers the US revenue streams and does not match them with the corresponding cost streams. A more efficient measure would be to use the net of the streams as it should reflect the true currency exposure. Due to limited data available, the US-sales-to-total-sales ratio is still used as it can be considered a decent proxy. An attempt to estimate the USD-denominated cost streams could result in a less reliable measure.

Other limitations in this thesis include the small sample of firms in the treatment group and the time period covered. As this thesis examines UK firms cross-listed in the US, the number of firms available are limited. As a consequence of the small sample of firms, the reliability of the findings could be affected. An improvement and a possible extension of this thesis could be to also examine UK firms cross-listed elsewhere. Such an extension could provide further substance to the findings.

Moreover, the selected estimation window only covers a short time period. Estimations may be affected by short-term market conditions and thus not provide a fully reliable estimate for normal performance.

This thesis contributes to previous literature by examining a relatively new, unexplored event in modern history. By employing methodologies used in previous literature on ADRs, this thesis adds to the research on ADRs and the currency exposure associated with these securities.

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7. Appendix

Appendix I: Treatment group

Table VIII: Summary of the selected sample of firms

The table consists of the selected sample of firms which have ADRs listed on NYSE or NASDAQ at the event date June 24th 2016. Exchange, domestic market capitalisation and ADR market capitalisation for each firm is included. Domestic market capitalisation and ADR capitalisation are denominated in USD millions. The total sample consists of 23 firms. The data is collected from Capital IQ and annual reports.

		Market capitalization (USDm)	
Company	Exchange	Total market	ADR
AstraZeneca	NYSE	86,045	9,293
Barclays	NYSE	54,225	1,535
British American Tobacco (BAT)	NYSE	103,319	2,087
British Petroleum (BP)	NYSE	95,880	27,815
BT Group	NYSE	57,777	474
Carnival	NYSE	44,045	324
Diageo	NYSE	68,591	11,908
GlaxoSmithKline (GSK)	NYSE	97,209	18,285
HSBC	NYSE	154,983	3,564
InterContinental Hotel Group (IHG)	NYSE	9,203	580
Lloyds Bank	NYSE	76,218	500
Midatech Pharma	NASDAQ	86	-
National Grid	NYSE	51,762	5,642
Pearson	NYSE	8,834	205
Prudential	NYSE	57,819	312
Royal Bank of Scotland (RBS)	NYSE	51,111	88
Relx	NYSE	36,834	591
Rio Tinto	NYSE	52,488	3,382
Smith & Nephew	NYSE	15,960	2,012
Summit Therapeutics	NASDAQ	135	46
Unilever	NYSE	122,425	15,975
Vodafone	NASDAQ	86,544	6,961
WPP	NYSE	29,843	1,756

Appendix II: Control group

Table IX: Summary of the selected control group for the difference-in-differences analysis

The table consists of non-UK ADRs used as a control group for the treatment group of UK ADRs. The sample is selected by employing a propensity score matching methodology. Domestic market capitalisation and exchange where the ADR is traded is included for each firm. The domestic market capitalisation is denominated in USD millions.

		Market capitalisation (USDm)
Company	Exchange	Total market
500.com	NYSE	840
Ambev	NYSE	70,655
Cheetah Mobile	NYSE	2,281
China Life Insurance Company	NYSE	114,851
Chunghwa Telecom	NYSE	23,314
Equinor	NYSE	44,370
Grupo Aval Acciones Y Valores	NYSE	7,651
Himax Technologies	NASDAQ	1,410
Infosys	NYSE	38,153
Korea Electric Power Corporation	NYSE	27,277
Novartis	NYSE	207,710
Novo Nordisk	NYSE	148,279
Perusahaan Perseroan (Persero)	NYSE	22,088
PetroChina Company	NYSE	222,078
Sanofi	NASDAQ	112,627
Sasol L	NYSE	16,538
SK Telecom Co	NYSE	9,218
Taiwan Semiconductor Manufacturing Company	NYSE	112,450
Telefonaktiebolaget LM Ericsson	NASDAQ	31,611
TOTAL	NYSE	105,268

Appendix III: Difference-in-differences match

Table X: Evaluation of match between treatment and control group

The table shows the mean beta, market capitalisation and price-to-book ratio for the final treatment and control group. A two-sided t-test is conducted to test if the means deviate from each other.

	Mean			t-test	
Variable	Treated	Control	Bias	t-test	p>| t |
Beta	0.607	0.6391	-0.037	-0.22	0.827
Mktcap	10.302	10.387	-0.039	-0.15	0.884
Pb	3.955	3.913	0.004	0.02	0.981

*Denotes a significance level of 10%

**Denotes a significance level of 5%

***Denotes a significance level of 1%

Appendix IV: Difference-in-differences graph

Figure III: Average abnormal returns for the treatment and control group

The figure illustrates the average abnormal returns across firms in percentage for the treatment and control group for the days surrounding the event date June 24th 2016 ("day 0"). The abnormal returns are calculated using the market model to obtain estimates for the predicted normal return with the S&P 500 as the proxy for the market return.