



The effects of research and development expenditure on long-term stock returns: An analysis of the BRICS nations.

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Abstract

Research and development (R&D) facilitate and drive innovation, which plays a critical role in increasing competitiveness for firms and contributing to economic growth. This study examines a sample of 970 firms from Brazil, Russia, India, China and South Africa (BRICS) between 2007-2020 who increased their R&D expenditure or had an unexpected increase in R&D expenditure from one year to the next. The Fama and French (1993) three factor and Carhart (1997) four factor models are used to assess whether these firms earned abnormal returns in the long run. The study finds that value weighted portfolios of firms that increased their R&D expenditure or experienced unexpected R&D expenditure increases exhibited long-term positive abnormal returns. This suggests that investors fail to respond immediately to the good news about R&D, consistent with the phenomenon of investor underreaction, and therefore presents an opportunity for market participants to earn abnormal returns by investing in BRICS companies engaged in R&D.

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List of acronyms

AMEX/ASE	American stock exchange
B/M	Book-to-market
BRICS	Brazil, Russia, India, China and South Africa
BRN	Brazilian real
BSE	Bombay stock exchange
CAPM	Capital Asset Pricing Model
DJIA	Dow Jones Industrial Average
E.U.	European Union
EMH	Efficient market hypothesis
FASB	Financial Accounting Standards Board
GAAP	Generally Accepted Accounting Principals
GDP	Gross domestic product
HML	Return on a portfolio of long stocks with high book-to-market ratios and short stocks with low book-to-market ratios
IAS	International accounting standards
IBOV	Ibovespa Brasil Sao Paulo stock index
IFRS	International Financial Reporting Standards
INR	Indian rupee
INV	Investment
JSE	Johannesburg stock exchange
MNCs	Multinational corporations
NASDAQ	National Association of Securities Dealers Automated Quotations Stock Market
NYSE	New York stock exchange
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least squares
OP	Operating profitability
P/E	Price-to-earnings

PPE	Property, plant and equipment
R&D	Research and development
ROA	Return on assets
RTS	Russian stock exchange
S&P500 Index	Standard and Poor 500 index
SMB	Return of a portfolio long small stocks and short large stocks
STI	Science, technology and innovation
TSE	Tokyo stock exchange
U.K.	United Kingdom
U.S.	United States
UMD	Momentum
ZAR	South African rand

1. Introduction

1.1 Background

Research and Development (R&D) incubates and facilitates innovative solutions and advancements. Internationalisation of R&D has been growing over the last few years which is evident through developments such as: progress in R&D in emerging economies; developed economies outsourcing R&D to developing economies; enhanced partnerships between R&D institutions and end-users; and growing commercialisation of R&D (Export Import Bank of India, 2014:76). For example, India has several mutual R&D agreements with developed nations, varying from a clean energy research agreement with the United States (U.S.) (Burns, 2007) to energy and water technologies with the European Union (E.U.) (Stamelos & Tsimaras, 2019)

Companies invest in R&D with the hope of retaining or increasing their competitive advantage. Such firms are believed to have greater technological capacities, expanded firm knowledge and increased innovation. Furthermore, R&D creates more advanced and improved processes which typically cost less to undertake and subsequently result in a lower cost of manufacturing (Steenkamp et al., 2018:1). Lower costs and improved processes can result in the desired competitive advantage and lead to growing profit margins.

Majority of economists agree that innovation plays a crucial part in creating and navigating economic growth and competitiveness (Moncada-Paternò-Castello et al., 2010). A study which analyzed countries in the E.U. established an association between innovation and economic growth in Portugal, Italy, Greece, Spain, Finland and Sweden, where innovation acted as a vital driver of economic growth (Bilbao-Osorio & Rodriguez-Pose, 2004). Furthermore, innovation has the potential to act as a pivot in addressing additional challenges such as developing skilled labour, diminishing global warming, eradication of diseases and assurance of safety and well-being for all (OECD, 2015). Innovation is especially important for emerging countries due to the prevalent and persistent wide disparity in the social and living standards measures in the respective nations (Blanco, Delgado & Presno, 2020).

An important measure which reflects the importance of innovation in each country is the ratio of the country's R&D expenditure to gross domestic product (GDP). According to the latest available data from the World Bank and the Organisation for Economic Co-operation and Development (OECD), R&D comprises 2.27% of world GDP, 3.07% of American GDP (2019), 1.76% of the United Kingdom's (U.K.) GDP (2019) and 3.24% of Japan's GDP (2019).

Relative to the developed nations, Brazil, Russia, India, China and South Africa (BRICS), which comprise some of the leading emerging markets, have the following percentages of R&D to GDP: Brazil 1.26% (2017), Russia 1.03% (2019), India 0.65% (2018), China 2.24% (2019) and South Africa 0.83% (2017). These figures therefore indicate that, apart from China, the BRICS economies lag some of the world's most developed economies with respect to R&D expenditure as a percentage of GDP. Despite this, the BRICS nations do realise the importance of R&D and have implemented measures to increase R&D in their respective countries and so contribute to economic growth.

With a robust manufacturing foundation and expert engineering labour force, Brazil is regarded as the front-runner in science and technology within South America. Furthermore, Brazil is also a leading participant in specialised innovative areas such as deep-water oil extraction and aerospace (Gupta et al., 2013). There has been growing investment in R&D in Brazil which has been underpinned by public policies aimed at creating and accelerating the growth of science and technology, for example lending and granting of non-reimbursable funds to Brazilian firms and tax incentives (Fabiani & Sbragia, 2014).

Russia has an extensive history of scientific research and several centres of excellence. Most of their R&D has continued to be undertaken by government owned research departments as former Soviet Union R&D firms are burdened and experience difficulty in navigating administrative and institutional legacies of the former command system (Trifilova, Bartlett & Altman, 2013). The government established 'The State Programme for Development of Science and Technology', from 2012 to 2020, with the goal to produce a dynamic and productive R&D department to be the catalyst for technological modernisation of the economy and reduce the country's dependency on oil and gas revenues (Filippov, 2011).

The establishment of several R&D centres of multinationals such as Google, IBM and Microsoft in India has fast-tracked India's integration into global research. Their demographic advantage, through expanding population and low age dependency, as well as a surplus of skilled labour has encouraged technological capabilities. The country has preferential tax treatment for expenditure on in-country R&D expenditure, for example they allow a 100% tax write-off on profits of innovation centred companies who are in their infancy stage (Saha & Shaw, 2018). Furthermore, India's government announced a 'Decade of Innovations' for the period 2010-2020, aiming to reach a level of 2% expenditure in R&D relative to GDP by 2020 (Export Import Bank of India, 2014).

In China, the science and technology sector is dominated by company centred market-based inventions, with businesses striving to achieve innovation-led development. China's open-door policy has resulted in substantial capital inflows in the form of foreign direct investment (Garnaut, Song & Fang, 2018) and the acceleration to the summit of worldwide value chains, on the other hand it has resulted in China becoming particularly dependent on overseas technologies (Walsh, 2003). Corporate and value added tax rates are continuously decreased for technology intensive businesses as the government aims to facilitate growth and technology transfer in software industries. In particular, the Chinese government have created two principal tax breaks, “the super deduction of R&D expenditures” and “preferential tax rates for new/high technology enterprises” (Jia & Ma, 2017).

South Africa’s government realises that current science, technology and innovation (STI) policies need to be updated to position themselves for potential economic growth and protection against the eradication of conventional jobs, in a majority unskilled labour force, as global economies and countries further their technological advancement (Dessus, Goddard & Hanusch, 2017). Hence, the release of the latest White Paper in March 2019, which concentrates on harnessing STI to facilitate broad and all-encompassing economic development, produce an economy which can compete globally, and upskill and enrich citizen’s livelihoods (Department of Science and Technology, 2019:10). The aim is to increase the levels of R&D outlay in South Africa to 1.5% of GDP by 2029.

1.1.1 Accounting treatment of R&D

Prior to 1976, the Financial Accounting Standards Board (FASB) found zero association between R&D costs and specific future revenue generation. This finding was the main contributor toward their verdict in 1974 to necessitate the complete write off of R&D expenditures in financial statements of listed companies. The Generally Accepted Accounting Principles (GAAP) therefore mandated the complete expensing of R&D in financial statements as U.S. standard-setters were engrossed with the reliability and objectivity of the approximations in relation to the capitalisation of R&D, which would have been reflected on the balance sheet, and the accompanying audit risk (Lev and Sougiannis, 1996).

The expense as incurred treatment has continued in the U.S. under GAAP, where firms are still required to recognise R&D spending in the same financial year that the expense is incurred. This accounting convention of R&D creates volatility through earnings for majority of firms, as well as in measuring their rates of return on assets and equity where expensing rather than

capitalising usually bolsters these return metrics (Cazavan-Jeny, Jeanjean & Joos, 2011). For example, when a company expenses R&D relative to capitalising it, the denominator in the Return on Assets (ROA) formula, namely total assets, would be lower and therefore the resulting ROA would be higher.

The International Financial Reporting Standards (IFRS) rules are applied in every BRICS nation, although the date of adoption of these rules varies across the countries. Similar to GAAP, IFRS requires that research expenditure is treated as an expense each year (IAS 38.54). However, it does differ to GAAP because it allows for development costs to be capitalised (IAS 38.57) if the firm can prove that the asset in development will become monetarily suitable i.e. the technology/product in development is likely to generate future revenue and get through the approval process.

The advantage for firms using the IFRS approach is that a portion of the R&D expenditure/cost can be capitalised and therefore an asset is created on the Statement of Financial Position, instead of being incurred as an expense on the income statement. However, the IFRS accounting treatment of R&D requires judgment and subjectivity, which creates a danger that managers will be excessively idealistic about the R&D expenditure in question, therefore allowing them to manipulate profits by hastening or postponing the amortisation of R&D spending on projects with a poor chance of succeeding, which can cause irregularities in financial statements (Lev & Sougiannis, 1996; Cazavan-Jeny, Jeanjean & Joos, 2011).

In theory, since U.S. firms are obligated to expense their full R&D expenditure in the same year, this would mean their R&D expenditure appearing on their income statements would be higher relative to non-U.S. companies who report using IFRS, as these managers need to distinguish between development activities (capitalised) and research activities (expensed) rather than expensing the full amount.

Therefore, due to its accounting treatment, R&D investments have a differentiating factor relative to other non-current assets. The cash outflow of an R&D increase is clearly more palpable since it is expensed, which is what this study focuses on, in divergence to the capitalisation which happens when an asset like property, plant and equipment (PPE) is enlarged. Moreover, the unrealised probable future advantages of R&D increases, highlight the intangible information regarding forthcoming cash flows. Despite, non-current assets also holding this intangible element, they fail to replicate a similar relationship and differentiation

amongst tangible and intangible information (Eberhart, Maxwell & Siddique, 2004) via U.S. GAAP and the expensed portion of R&D under IFRS.

1.2 Problem statement

Evaluating the association between R&D spending and consequent market performance has been extensively studied and examined. Two contending theoretical arguments have been proposed for the positive association between R&D expenditure and subsequent market performance. In theory, the association can be credited to either market compensation for risk brought about by R&D outlays, or to market mispricing (Anagnostopoulou, 2008). The evidence largely indicates a positive association between R&D and subsequent market performance (Souigiannis, 1994; Al-Horani, Pope & Stark, 2003; Xu & Zhang, 2004). The studies conducted on the influence of R&D spending, however, have been conducted almost exclusively on developed economies, namely the U.S. and the U.K. The focus of the literature therefore raises issues of generalisation of empirical results as there has also been little research conducted in developing markets.

Some research has considered the influence of R&D on stock market performance in the BRICS nations. Bhana (2013) found that R&D investments by firms listed on the Johannesburg Stock Exchange (JSE) are consistently undervalued and therefore concluded that investors systematically undervalue the intangible information contained in the R&D spending announcements. Ramaboa and Chen (2017) demonstrated that South African firms who undertake R&D outlays endure a marked degree of positive abnormal returns, and outperformed their counterparts who had not undertaken R&D in the long-term. Differing results were found in other BRICS countries. For example, in India an inverted U-shaped association between R&D intensity and firm value for manufacturers was observed (Naik, Narayanan & Padhi, 2012). An inverted U-shape means that as R&D expenditure increased so does firm value, however beyond a certain threshold level of expenditure, any further increases in R&D expenditure, result in a decline in firm value. Similarly an inverted U-shaped relationship was found in China for public companies on the Shanghai and Shenzhen exchanges (Kim, 2018).

To the best of the author's knowledge, the aforementioned studies are the only academic literature that has been conducted in the BRICS nations on the topic of the association between R&D and firm value, which highlights that it is particularly scarce. Moreover, for South Africa, most of the research has focused on announcement effects or balance sheet-based effects on

the relationship between R&D expenditure and firm value (Bhana, 2001; Bhana, 2013; Ramaboa & Chen, 2017) as opposed to long-term abnormal returns.

Consequently, it is thus not known whether the positive association between R&D spending and subsequent market performance demonstrated internationally is true in the BRICS countries, especially focused on the increase in R&D on the income statement compared to the capitalised portion found on the balance sheet.

There are several motivations for the analysis of R&D in the BRICS countries. In recent years there have been a multitude of efforts from the respective governments to promote spending on R&D as discussed in section 1.1. Furthermore, the BRICS countries are among the largest of the developing markets and are poised to be some of the fastest growing economies in the world with the aid of technology and R&D, which present the opportunity for attractive returns for investors due to their riskiness relative to developed markets.

One of the most important reasons for investors to know what the relationship is between R&D spending and returns in the BRICS countries is to ascertain whether the markets correctly value R&D spending. If it is found that investors do correctly value R&D spending it may encourage firms to take up more R&D. R&D has a positive and significant link to innovation, which plays a crucial part in creating and navigating growth and employment, two things which the developing BRICS countries desperately need. The implications for firms who forego current R&D expenditure in order to “prop up” their financials through decreased expenses, would be a lack of competitiveness and even threatening their going concern in the future. The implications for investors of the findings of this study would be to investigate whether they can earn abnormal returns and beat the market by investing in companies who have positive and unexpected R&D expenditures.

1.3 Research question and objectives

This study aims to answer the question: What is the effect on the long-term share price performance of firms in the BRICS countries following *expected/total* and *unexpected* R&D expenditure increases?

The main objective of this study is to evaluate if R&D expenditures result in abnormal returns across the BRICS nations and, as such, assess whether a similar mispricing, which has been demonstrated in the U.S. and U.K. markets exists. Furthermore, an analysis of each of the respective BRICS nations on their own are used as robustness tests. The study focuses only on the R&D expense portion found on a company’s income statement and not the capitalised

portion found on the balance sheet. The study examines the following markets for the respective BRICS countries: the Sao Paula exchange (Brazil), Moscow Exchange (RTS) (Russia), Bombay stock exchange (BSE) (India), Shanghai/Shenzhen stock exchanges (China) and the JSE (South Africa).

1.4 Structure of the study

The remainder of this study is structured as follows. In Chapter 2, the theory and existing empirical literature, both in developed and developing nations, on the topic is reviewed. Chapter 3 discusses the data and methodology of the paper. Chapter 4 presents and draws inferences from the empirical results. Finally, chapter 5 provides the conclusions and suggestions for further research.

2. Literature review

2.1 Introduction

This chapter begins by explaining the Efficient Market Hypothesis (EMH) and the incorporation of firm information, such as R&D expenditure, into a firm's share price, which provides the theoretical framework upon which the study is developed. Thereafter this chapter reviews studies that have been conducted in developed markets on the relationship between R&D and firm performance. The chapter concludes by discussing similar studies that have been conducted in the BRICS nations.

2.2 Theoretical framework

Fama's 1970 theory of the EMH maintains that stock prices completely incorporate all information, and any new information is instantly reflected in the stock price (Malkiel, 2003). A key assumption underpinning the EMH is that investors are rational and respond appropriately to new information. The EMH has three forms which differ relative to their definition of 'available information' namely, weak, semi-strong and strong form.

The weak form of the EMH states that all past information which can be obtained from analysing market trading data such as historical prices, volume of trades or short interest are already priced into securities. Such information is openly accessible and practically costless to retrieve. The weak form thus proposes that market participants would have already garnered the know-how to exploit the information, which in theory gives reliable indications regarding future performance. Eventually, the indications become worthless when the information becomes common knowledge within the market, and thus trend analysis is rendered to be ineffective (Bodie, Kane & Marcus, 2014).

The semi-strong tenet of the EMH articulates that the entirety of publicly available information should already be incorporated into security prices. All publicly available information comprises past prices, essential data regarding the company's product line, quality of management, balance sheet composition, patents held, earning forecasts, and accounting practices (Bodie, Kane & Marcus, 2014). The semi-strong form of market efficiency thus proposes that neither fundamental nor technical analysis can afford any benefits for market participants. Moreover, new public information is instantly reflected in stock prices (Titan, 2015).

The strong form of market efficiency states that stock prices reflect the entirety of both public and private information concerning a particular company and that no investor can be afforded

any advantage over the market (Titan, 2015). This tenet of the EMH is, however, unrealistic, as insider trading is illegal. Furthermore, it does not articulate that particular investors or money managers cannot capture abnormal returns, but rather it states that investors and money managers cannot consistently earn abnormal returns as any pricing errors will not persist, but instead disappear quickly because of the actions of market participants to try and beat the market (Bodie, Kane & Marcus, 2014).

R&D expenditure is fundamental information found within a firm's financial statements. Thus, if markets are semi-strong efficient this would result in a firm's share price immediately and fully responding to an increase/change in R&D expenditure as soon as the firm's financial statements are released given the fact that it is considered to be publicly available information. Increases (decreases) in R&D are likely to increase (decrease) share prices because R&D expenditure is likely to yield future benefits for the company, for example improved processes resulting in lower costs or the development of a new unique product. As such, if markets are efficient, we would not expect to see an overreaction or underreaction due to the R&D changes but a movement in the share price corresponding to the meaning of the new information. However, most cases studies have findings of long-term abnormal stock returns which are related to a specific corporate event, which suggests that investors underreact to new information (Kadiyala & Rau, 2004). That is, good (bad) information regarding a firm is revealed to the market, and assuming the market is efficient, the share price increase (decrease) would be immediate and to the true value which incorporates this new piece of positive (negative) information. But if the market is inefficient or weak-form efficient and investors are slow to react (i.e. they are not rational) then it will take time for the price to increase (decrease). The price will rise (fall) gradually which will give rise to the opportunity for investors to earn abnormal returns.

On the other hand, in their analysis of the behavioural hypothesis of investor underreaction, De Bondt and Thaler (1985, 1987) discovered systematic price reverses for shares which had extreme long-term gains or losses i.e. previous losers significantly outperformed previous winners as investors overreacted to new information and prices became too inflated. These prices subsequently corrected over time and resulted in losses, therefore indicating that investor overreaction is also particularly prominent.

In his analysis of the efficiency of capital markets, Fama (1970) inferred that market efficiency alone is not testable and the way in which the market reflects information should also be

declared i.e. there needs to be an asset pricing model in place which reflects how market participants obtain information and thereafter set asset prices with such information. When utilising an asset pricing model, predictions can be formed which can also be observed and tested. Thus, the testing of market efficiency is a joint test of the EMH theory and an asset pricing model, such as the capital asset pricing model (CAPM). This is what is referred to as ‘the joint hypothesis’ (Jarrow & Larsson, 2012).

Accordingly, if abnormal returns are identified with corporate events, or in this case R&D expenditure, it may not be due to irrational behaviour but rather due to an insufficient measure of risk in the asset pricing model. For example, the CAPM beta has been shown to not be able to capture the risk associated with corporate events such as seasoned equity offerings relative to models such as that of Fama and French (1993) (Fama & French 1992; Kadiyala & Rau, 2004). The CAPM also fails to capture the risk associated with firms who have high R&D expenditures as demonstrated in prior study results (Eberhart, Maxwell & Siddique, 2004; Ali, Ciftci & Cready, 2012; Songur & Heavilin, 2017). Moreover, the problem of not being able to ascertain where the abnormal returns can be accredited is because of the joint hypothesis problem i.e. when tests are performed, it is necessary to assume EMH and CAPM hold and so if the null hypothesis is rejected and therefore concluded that there are abnormal returns it could be due to the failure of the EMH to describe the behaviour of investors (i.e. they are not rational) and/or the CAPM is a poor model.

Furthermore, studies have used expanded measures of risk like the Fama and French three factor model and still found abnormal returns (Eberhart, Maxwell & Siddique, 2004; Ali, Ciftci & Cready, 2012; Songur & Heavilin, 2017). The fact that abnormal returns have still been found in the context of using expanded models means either market inefficiency or an inappropriate measure of risk (i.e. the expanded models could still be flawed), which applies generally and in the context of R&D.

2.3 Overview of empirical studies

A number of papers were written relating to the subject of R&D and subsequent market performance prior to 1994 (Ben-Zion, 1978; Hall, 1993; Cockburn & Griliches, 1988). Methods undertaken in these studies ranged from Tobin’s Q to market value (price), the market-to-book ratio and abnormal returns, with all documenting a positive association between R&D and succeeding market performance (Anagnostopoulou, 2008).

Research conducted post-1994 (such as Chambers, Jennings & Thompson, 2002; Al-Horani, Pope & Stark, 2003; Eberhart, Maxwell & Siddique 2004), has evaluated the relationship between R&D spending and subsequent market performance/firm value through the use of either a market value/price return model or by assessing risk-adjusted returns for R&D intensive companies over a certain period (Anagnostopoulou, 2008).

The majority of papers which have explored the relationship between R&D expenditure and subsequent firm value or market performance focused on developed markets. The dominant finding is of a positive relationship between the two variables, although some studies have found no relationship. Several studies also seek to explain the finding of abnormal returns i.e. whether it is behavioural-based or due to an insufficient measure of risk (as per the joint hypothesis problem). The reviews of these studies are grouped according to their findings in the sub-sections below focused on the U.S., followed by the U.K and Europe and finally Japan. Thereafter, research that has been conducted in emerging markets, specifically in the BRICS nations, is examined.

2.4 Studies conducted in developed markets

2.4.1 *Positive relationship*

Sougiannis (1994) examined whether accounting earnings appearing in financial statements of listed U.S corporations on the New York stock exchange (NYSE) and American stock exchange (AMEX/ASE) between the years 1975-1985 reflected benefits from prior R&D spending and uses such benefits (if present) to approximate the investment value of R&D. The author used cross-sectional data to approximate a recursive system of two equations: intended for earnings and valuation. The earnings equation linked earnings with documented assets, advertising, and R&D spending. Moreover, it extracted realised R&D benefits from earnings figures in the financial statements. On the other hand, the valuation equation linked the ratio of market value of equity to book value, earnings, and R&D spending, with the equation determining the manner in which accounting and R&D figures are given a valuation within the market. Both equations assumed that prior R&D generated earnings which in turn created market value. The coefficients obtained via the two equations were utilised to approximate the investment value of R&D. The results from Sougiannis's (1994) valuation model indicated that investors assigned a substantial value toward R&D investments. The aggregated results revealed that a dollar rise in R&D resulted in a two-dollar rise in profit through a seven-year period and a five-dollar rise in market value over the same period. The long-term influence of R&D on market value comprised of an indirect and a direct effect. The indirect effect was the

capitalised value of realised R&D benefits mirrored in earnings and was projected to carry on in later periods, which is unique from the R&D capitalisation under IFRS – this is “self-determined capitalisation” based on earnings. The direct causation was associated with new R&D information conveyed directly by R&D factors. On average, the indirect causation was far larger than the direct causation, which revealed the value of earnings and implied that R&D variables were valued conditional on earnings.

Lev and Sougiannis (1996) aimed to address the problems related to reliability, objectivity, and value-relevance of R&D capitalisation. The study first estimated the association amongst R&D spending and consequent earnings for a substantial cross-section of R&D-intensive companies. The estimation allowed for the computation of company related R&D capital and its amortisation rate and the measurement of the periodic R&D amortisation, which is opposite to the GAAP treatment of R&D where the full amount of the R&D expenditure is expensed. The study adjusted the stated earnings and book values of companies in the sample for R&D capitalisation. Lev and Sougiannis (1996) found a significant relationship between adjusted earnings values, stock prices and returns, which therefore highlighted the value-relevance to market participants of the R&D capitalisation method. Additionally, an important intertemporal association amongst firms' R&D capital and subsequent stock returns was observed. The estimated R&D capital did not appear to be fully reflected contemporaneously in stock prices, since R&D capital was associated with subsequent stock returns, either attributable to a systematic mispricing of R&D-intensive firm stocks, or a reward for an additional market risk factor related to R&D, not captured by the asset pricing model. It was concluded that R&D capitalisation yielded statistically reliable and pertinent economic information, which contradicted the FASB prior findings as described in section 1.1.1.

Chambers, Jennings and Thompson (2002) analysed all NYSE, ASE, and National Association of Securities Dealers Automated Quotations (NASDAQ)-traded firms between 1979 and 1998 and, similar to Lev and Sougiannis (1996), found a positive relationship amongst the levels of R&D outlay and subsequent abnormal returns. Prior studies on the subject had not provided concrete findings on whether abnormal returns to companies engaged in R&D was as a result of mispricing or risk not captured by the model used. Accordingly, Chambers, Jennings and Thompson (2002) sought to assess whether excess returns to R&D-intensive companies were caused by an insufficient control for risk by examining (i) if the returns continued over time, (ii) if returns were more highly variable than returns on non-R&D intensive firms, and (iii) if measures of earnings ambiguity were correlated with R&D intensity after controlling for risk

via the Fama and French (1993) factors. Their findings showed that relative to companies who effectively has zero R&D outlays, those firms who had engaged vigorously in R&D earned abnormal returns which continued for up to ten years. Furthermore, the future abnormal return variability could not be diversified away within a portfolio of companies who had engaged vigorously in R&D and therefore had substantial R&D outlays. They concluded that the observed positive relationship amongst R&D outlays and abnormal returns was probably due to a failure to control sufficiently for risk as opposed to mispricing. Conversely, the findings did not rule out the prospect of an additional source of returns as a result of mispricing related to variations in the level of R&D outlays.

Eberhart, Maxwell and Siddique (2004) analysed long-term abnormal share returns of U.S. firms following an unexpected increase in R&D. The authors argued that investors believe that when firms grow, their expenditure on R&D will naturally grow; hence only unexpected increases in R&D should impact stock prices. The research defined an unexpected R&D increase as an increase in a company's proportion of R&D to assets by an economically significant amount of 5% and the R&D intensity (the ratio of R&D to assets and R&D to sales) to also be above 5%. The sample comprised of 8313 cases between 1951-2001. The study found that over the five-year period succeeding their unexpected R&D rises, firms experienced significant positive abnormal stock returns. Furthermore, the study observed that the analysed companies experienced significantly positive long-term abnormal operating performance subsequent to their unexpected R&D rises.

In a related study, Lev, Radhakrishnan and Ciftci (2006) examined future excess returns of "R&D leaders and followers", asserting that R&D activities are not all of the same nature, and companies deliberately select to be "R&D leaders or followers". Additionally, they examine whether the excess returns following R&D increases are a result of mispricing or risk. The study used the proportion of R&D expenditure to sales and R&D expenditure to market value as proxies for gauging R&D intensity. The results of Lev, Radhakrishnan and Ciftci (2006) showed that the difference in future annual excess returns between the two sample groups were 0.99%, 7.58%, 3.93% and 2.44% from years one to four respectively. Further analysis revealed that despite the fact that a portion of the excess returns could be attributed to an incomplete risk adjustment, the majority of the second- and third-year excess returns resulted from delayed reaction by investors. The conclusion of Lev, Radhakrishnan and Ciftci (2006) thus differs from that of papers who attributed the excess returns to insufficient adjustments for risk (Chambers, Jennings & Thompson, 2002; Al-Horani, Pope & Stark, 2003).

Also examining the U.S. market, Hsu (2009) studied the impact of cumulative hi-tech inventions on anticipated market returns and premiums. The paper utilised the summation of all patents and previous industry R&D expenditures and detrended the growth rates to measure the cumulative hi-tech inventions and, subsequently, the growth rates in the cumulative hi-tech level to measure technological growth. Based on predictive regressions, Hsu (2009) found that both patent and R&D shocks had significant predictive power for the real and excess returns on the Standard and Poor's 500 (S&P500) index. Furthermore, the methodology was also applied to China, Italy, Canada, Germany, U.K., France, Japan, and India. The findings revealed that R&D shocks specifically related to each nation were positively correlated with future market returns and premiums in every nation bar France.

Ehie and Olibe (2010) also examined firms in the U.S. covering the period 1990-2007. They focused on manufacturing and service firms given the small amount of research that has focused on the impact of the differences between the two types of firms on the relationship between R&D expenditure and firm performance. The authors used R&D expenditure to net revenue rather than capitalised R&D to revenue as a measure of R&D intensity because they believed that companies had been tight-pocketed and therefore created an impotence for deriving an economic amortisation rate. This was utilised in favour to a complete R&D outlay level which related to firm size and may have confused the impact R&D outlay has on market performance of a firm, since capitalised R&D is found only on the balance sheet and is not common in America. Ehie and Olibe (2010) observed that R&D investments generated positive returns that were statistically significant for all firms. In addition, the same finding was observed for both the sub-samples of the manufacturing and service firms.

Ali, Ciftci and Cready (2012) investigated why companies who raise their R&D expenditure are subject to positive abnormal returns in later periods. Using the same methodology as Eberhart, Maxwell and Siddique (2004), they first confirmed that firms on the NYSE, AMEX, and NASDAQ with positive R&D expenditure between the years 1975-2006, who unexpectedly increased their R&D, earned abnormal stock returns. Thereafter, they used a returns model to analyse the relationship among R&D increases and subsequent earnings implied in ticker prices. Ali, Ciftci and Cready (2012) observed that the market underestimates the influence of R&D expenditure rises on earnings and abnormal returns that occur in subsequent periods. Furthermore, they observed that the future abnormal returns were particularly pertinent at earnings announcements. It was concluded that the abnormal returns were not likely a result of omitted risk factors on their own, but rather that a portion of the

future abnormal returns were likely because of the market's underestimation. The underestimation was due to ample volumes of information related to a company's performance engaging the market over earnings announcement periods, with the rectification of the mispricing quite pertinent around such announcements. The conclusion of Ali, Ciftci and Cready (2012) is similar to the findings of Lev, Radhakrishnan and Ciftci (2006) that the positive relationship may be due to the irrational behaviour of investors as opposed to an insufficient measure of risk as per Chambers, Jennings and Thompson (2002).

Similar to Eberhart, Maxwell and Siddique (2004), Songur and Heavilin (2017) analysed if a portfolio comprising firms with positive abnormal R&D investment changes outperformed the market portfolio from a sample of 4561 firms over the period 1975–2015 for all local stocks listed on the NYSE, AMEX and NASDAQ. The study categorised stock into three sub-samples: (1) small and large, (2) high- and low-tech, and (3) high- and low-growth due to previous literature which suggested a differentiation amongst R&D investments and share returns in relation to size, technological endowments and investment opportunities. The study revealed abnormal positive R&D investment returns, with the alpha values ranging between 46 and 97 basis points per month. The study further found that in all sub-samples, the increase in R&D resulted in significantly higher abnormal share returns relative to the market portfolio, regardless of the size, growth and/or technological endowment. Analogous to Eberhart, Maxwell and Siddique (2004), the authors concluded that owing to partial investor attention and complexities of processing information that is less concrete and more obtruse, share prices do not completely and immediately reflect the relevant public information about unexpected R&D changes.

In a recent study, Gosen (2020) analysed U.S.-based technology firms included in the NASDAQ100 and Dow Jones Industrial Average (DJIA) indices between 2010 and 2020. The DOW30 was included because the author believed investors tended to hold 'mega cap' shares in their portfolio. The study used four variations of R&D intensity since different accounting treatments could yield varying results. Two variables were created utilising the direct expensed R&D and the remaining two were created using the capitalised and amortised value of the R&D. By using four variables the study analysed both accounting treatments of R&D, in particular by using the capitalised and amortised value of the R&D, the study explored the effects of U.S. companies applying IFRS instead of U.S. GAAP. The findings show a robust relationship between high R&D intensive firms and abnormal share returns, where high R&D firms outperformed non-R&D firms on average by nearly 4 percent annually. However, for

firms with a lower R&D intensity the relationship with abnormal returns was weaker. It was concluded that the level of R&D intensity could describe the abnormal share returns of U.S. technology firms.

As highlighted previously, the early studies of Sougiannis (1994), Lev and Sougiannis (1996) and Chambers, Jennings and Thompson (2002) documented the positive association between R&D expenditure and performance in the U.S., while little investigation had occurred in the U.K. Importance must be given to the fact that U.K. GAAP has always permitted the capitalisation of particular R&D expenditure, although capitalisation of R&D in the U.K. prior to 2005 was infrequent (Tsoligkas & Tsalavoutas, 2011). Thus treatment of R&D expenditure in the U.K. prior to 2005 was similar to the U.S. i.e. being expensed in the same year it was spent and appearing on the income statement. Post 2005, IFRS became mandatory in the U.K. (Anagnostopoulou, 2008). However, the only difference between U.K GAAP and IAS 38 under IFRS is that capitalisation of R&D expenditure results from application of the standard as opposed to the choice of the manager in question (Tsoligkas & Tsalavoutas, 2011).

Countries within the E.U. have been mandated to use IFRS since 2005 in an effort toward harmonisation of accounting treatments which had differed markedly among member states (Cazavan-Jeny, Jeanjean & Joos, 2011; Duqi & Torluccio, 2013) i.e. they need to distinguish between research activities, which are and continue to be expensed, and development activities, which are capitalised so long as the company can provide evidence that the technology or product in development would meet the definition of an intangible asset and produce revenues (IAS 38.57). Therefore, it would be expected that the E.U. nations would have lower R&D expense amounts relative to the U.K. and U.S., which would then impact the findings as firms with lower R&D expenses have smaller subsequent returns/firm value. However, due to the difficulty and subjectivity when applying the IFRS treatment of R&D, there is a belief and evidence that most firms in majority of countries expense all forms of R&D expenditure in the year they are spent (Damodaran, 2008). Furthermore, despite the E.U. move to IFRS in 2005, disclosure of annual R&D expenditures in countries such as France, Germany and Italy is not mandatory (Hall & Oriani, 2006).

Toivanen, Stoneman and Bosworth (2002) analysed data for the period 1988–1995 on British companies earning in their local currency (pounds) with their primary revenue drivers in mineral mining, manufacturing, consumer goods or utilities. The study used an extension of Tobin's Q where the value of a firm reflected the market belief of the movement of subsequent

period profits and dividends, which were partially derived from a firm's tangible assets and partially by their intangible assets created by R&D activity. Market value was calculated as the summation of company equity and debt. Mainly due to a short data series, book values of assets were used as a proxy for total assets rather than a calculated using a depreciation formula. Toivanen, Stoneman and Bosworth (2002) found that companies who spent on R&D for the first time in 1989 showed a larger influence of R&D on market value in that year than companies who engaged in R&D pre-1989. Additionally, no evidence was found to conclude that the market values R&D to a greater extent for higher market capitalisation companies. The main conclusion was that the U.K. market values R&D as had been found in earlier studies in the U.S. i.e. the existence of a positive association.

A further study of the relationship between R&D activity (defined as the ratio of R&D expenditure to market value of equity) and stock returns in the U.K. was conducted by Al-Horani, Pope and Stark (2003), who analysed every U.K. listed non-financial company for the financial years ending 1990-1999. They found that the cross-section of U.K. share returns had a positive relationship to R&D activity, moreover the relationship was significant even when the market value of equity and book to market ratio of the firms were controlled for. In the second stage of the analysis, Al-Horani, Pope and Stark (2003) modified the Fama and French (1993) three-factor asset-pricing model to account for possible R&D effects. In this regard, the research found that the explanatory power of factors had improved following the control for R&D activity, as the three factors partially captured effects associated with R&D activity, specifically for portfolios of companies who had not engaged in R&D. Similar to Chambers, Jennings and Thompson (2002), these findings suggest that a risk-based description, instead of a behavioural based description, existed in explaining why R&D expenditure appeared to give rise to abnormal returns.

Duqi, Mirti and Torluccio (2011) assessed the influence of R&D outlays on share returns using cross-sectional regressions after controlling for market capitalisation, stock price, R&D expenditure, debt, price-to-book value and R&D stock (R&D capital/market value of equity) at the firm as well as country level. The sample consisted of 6921 listed firms forming part of what was considered the most important industrialised nations within the E.U. at that point in time, those being, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Portugal, Spain, Sweden and U.K. for the years 1999-2010. The sample was split into three sub-samples, (i) firms who spent on R&D between 2006-2010 continuously, (ii) firms who spent on R&D in at least one year and (iii) the top quarter of firms who spent continuously

in R&D, which were considered to be the more R&D intensive and advanced of the overall sample. Companies listed in the U.K., France and Germany made up over 60% of the sample, because they had higher R&D expenditures. Duqi, Mirti and Torluccio (2011) found that the inclusion of the R&D variable tended to improve the overall significance level in the regressions. The findings were further backed by detecting significant coefficients for firms who had only undertaken R&D infrequently, within customised sub-samples. The study concluded that the effect of R&D on share returns was greater in nations that spend more on R&D compared to others on average, which differs to Hsu (2009) who found insignificant results for France.

In a subsequent study, Duqi and Torluccio (2013) again examined the impact of R&D on the valuation of European companies albeit with a different sample and method. The sample comprised the R&D expenditures of the top 1,000 non-financial listed companies in the E.U. that invested the greatest amount in R&D over the period 2001-2007, which were in the U.K., Germany, France, Sweden and Italy. The study used a residual income model where firm value was linearly related to its book value, residual income and R&D expenditure. Duqi and Torluccio (2013) found a positive impact of R&D outlays on firm market value in all countries examined, except Italy. The study concluded that the effect of R&D expenditures on market value was greater for companies operating in hi-tech sectors as investors appreciate R&D intensity in such companies as a signal for cash flows in future periods.

Other factors which have been shown to impact market valuations in relation to R&D expenditures in several European nations outside of the U.K. and U.S include the size of financial markets, data availability problems, ownership structures and law systems (Hall & Oriani, 2006; Duqi, Mirti & Torluccio, 2011; Duqi & Torluccio, 2013).

Beyond the U.S., U.K. and Europe, the association between R&D expenditure and share returns has also been examined on the Japanese market. Xu and Zhang (2004) analysed the relationship between share returns and R&D intensity for Japanese companies listed on the Tokyo Stock Exchange (TSE) from 1985-2000. The sample period was divided into the following subperiods: (1) the bubble-forming period from 1985-1989, (2) the burst-of-bubble period from 1990-1992, and (3) the post-bubble period from 1993-2000. The paper measured R&D intensity as R&D expenditure to total assets as well as to book value of equity. The authors put forward that the decision on the amount of R&D expenditure should be practically independent of how funding was attained. Therefore, R&D intensity only depends on capital structure to a

relatively small extent, which favours R&D expenditure to total assets over R&D expenditure to book value of equity/market value of equity. Furthermore, R&D expenditure is relatively stable, which emulates a comparatively enduring strategy of a company, whereas sales and earnings oscillate over time. Xu and Zhang (2004) therefore argued that using sales and earnings as denominators to normalise R&D expenditure made the subsequent variables of the R&D intensity more volatile than they actually were.

Using a cross-sectional regression approach, Xu and Zhang (2004) found that the mean share return was positively associated to R&D expenditure. However, it was not constant over the three subperiods of the sample. In the bubble forming period, the mean return was partially negatively related to R&D intensity. In the burst-of-bubble period, the relation was partially positive. Only in the post-bubble period was the R&D effect positive and significant. The authors concluded that the R&D intensity is supportive in explaining the expected share returns on average, however the association was weak.

2.4.2 No relationship

Chan, Lakonishok and Sougiannis (2001) assessed the ability of share prices to completely encompass a company's intangible assets, concentrating exclusively on R&D. The sample consisted of all local companies listed on the NYSE, AMEX, and NASDAQ between 1975-1995. The research methodology was based on an investment policy of R&D intensity. Two measures of R&D intensity were used, R&D expenditure to sales and the proportion of R&D expenditures to the market value of equity. Portfolios were compiled at the end of April on an annual basis using the latest accessible accounting information while allowing for a four-month delay between the end of a company's fiscal year and the publication of its financials. Shares were ranked by a measure of R&D intensity and allocated to one of five portfolios. Equally-weighted annual buy-and-hold returns were calculated over each of the three years following portfolio formation. The findings of Chan, Lakonishok and Sougiannis (2001) reveal that the mean share returns of companies with R&D matched the returns of companies without R&D. The paper thus concluded by noting that the absence of any differences agreed with the idea that the market price, on average, completely encompasses the benefits of R&D spending, which differs markedly from the seminal findings of Eberhart, Maxwell and Siddique (2004). A reason for the difference could lie in the fact that Eberhart, Maxwell and Siddique (2004) analyse both R&D intensity and unexpected increases of R&D (R&D/assets increasing) when forming their portfolios, whereas Chan, Lakonishok and Sougiannis (2001) only focus on R&D intensity. The most pertinent signs of a relationship between R&D intensity and subsequent

period returns originated from shares with high R&D relative to market value of equity which had tended to perform poorly in prior periods.

Nguyen, Nivoix and Noma (2010) examined Japanese companies listed on the TSE between January 1998-June 2007 in order to assess if a similar mispricing, which had been demonstrated in the U.S. and U.K. markets, existed in Japan. The research used three different methods: cross-sectional regressions of share returns on lagged R&D, time series regressions of R&D-sorted portfolio returns, and buy-and-hold returns adjusted for matched-portfolio returns. Each method involved controls for the size and book-to-market characteristics which had exhibited high correlations with R&D intensity. It was found that companies who had been vigorously engaged in R&D did not exhibit abnormal returns. When outperformance was detected in down markets, Nguyen, Nivoix and Noma (2010) found that it could be accredited to a lower book-to-market ratio and the matter of growth firms having historically proven to perform better in bad periods. When R&D firms tended to trail in up markets, this could be attributed to their large size and that such firms underperform in good times. The paper concluded by finding no indication of mispricing in the Japanese stock market in contrast to Xu and Zhang (2004) who found that the mean share return was positively associated to R&D expenditure and Eberhart, Maxwell and Siddique (2004) who had found evidence of mispricing in U.S. markets and Al-Horani, Pope and Stark (2003) who had found similar evidence in U.K. markets.

Li, Lin and Hong (2012) researched whether R&D increases are advantageous actions for listed companies in Taiwan and the validity of the EMH subsequent to increases in R&D expenditure. The paper constructed a model of insider trading to study the information contained in R&D increases, while also making use of the Fama–French (1993) three-factor model to compute abnormal returns. The paper found there to be no significant abnormal returns for companies who had increased their R&D and therefore concluded that R&D may not be beneficial investment actions. They further concluded that even if R&D increases could bring higher share prices, they could not result in long-term abnormal share returns since valuable information portions of R&D expenditures were gradually exposed and therefore the semi-strong form of the EMH could not be rejected with R&D increases.

2.5 Studies conducted in the BRICS nations

There has been far less research conducted on the effect of an increase in R&D spending on firm value in the BRICS nations and developing countries more generally. To the best of the

author's knowledge there has been no papers on the subject matter in either Brazil or Russia. However, there has been some research conducted in India, China and South Africa.

Naik, Narayanan and Padhi (2011) analysed the relationship between R&D expenditure and company performance in the India between 1999-2008, based on a sample of 262 BSE-listed electrical machinery and electronics goods manufacturing companies. The study assessed the comparative effect of R&D when firm characteristic variables such as advertising, firm size, age of the firm, technology imports, export of goods, capital output ratio, financial leverage and foreign equity participation were present. Furthermore, the study used the Ordinary Least Squares (OLS) and fixed effects models to observe the determinants of company performance. The findings revealed the existence of a positive and significant association between a firm's R&D activities and its performance measures. However, the study did not control for risk and therefore can be viewed as a shortcoming of the authors' study in India. Furthermore, firm size, technology imports, capital intensity and financial leverage were established as additional central causes of profitability.

Naik, Narayanan and Padhi (2012) later examined the impact of R&D expenditure and market performance using a larger sample of 326 BSE listed manufacturing firms between 2001-2010. An inverted U-shaped association between R&D intensity and firm value was found following the control of firm specific variables, which indicated a diminishing marginal return to each Indian rupee spent on R&D. It was therefore concluded that R&D investments had a positive impact on the market value of a company initially, however when the amount surpasses an optimal point, R&D results in a negative influence on company value.

Turning to China, Kim (2018) studied the association among R&D and firm value for 563 firms listed on the Shanghai and Shenzhen exchanges between 2005-2013. Similar to Naik, Narayanan and Padhi (2012), Kim (2018) found that R&D investments have an inverted U-shaped association with company value, which indicated that as R&D investments rise, company value rises to a certain level and then declines.

An event study by Bhana (2001) investigated the short-term market reaction to R&D expenditure announcements by JSE-listed firms for the period 1980-1997. This study compared the market reaction to R&D announcing companies and companies operating in the same industry of similar revenue size but without R&D announcements, during the 15-day trading periods before and after the R&D announcements. It was observed that announcing companies earned a statistically significant two-day abnormal return of 1.19% and counterpart companies

suffered a two-day abnormal return of -0.56%. Bhana (2001) thus concluded that the signal that the announcing company gains a lead in the R&D race dominates the signal that non-announcing companies might benefit from technology spill overs.

Adding to his earlier work, Bhana (2013) analysed a sample of JSE-listed firms who announced increases in R&D expenditure (93) for the years 1995-2009. The study made use of the same screening requirements as Eberhart, Maxwell and Siddique (2004), and buy-and-hold period returns to obtain the long-term abnormal returns. The study obtained similar results to Eberhart, Maxwell and Siddique (2004) and found that for the 3-year period following the announcements, there was consistently strong evidence that the announcing companies experienced significant positive abnormal operating performance. Additionally, it was observed that shareholders experienced significant positive abnormal share returns for three years subsequent to the increased R&D expenditure announcement. It was concluded that JSE investors systematically undervalued the intangible information within the R&D spending announcements.

Ramaboa and Chen (2016) examined the impact of R&D capitalisation (which differs to studies that focused on R&D expenditure as this capitalised portion would reflect on the balance sheet rather than the income statement) on the valuation of equities of South African listed companies between 2000-2014. The study formed portfolios with comparable price-to-book ratios and market size to detect any signal of subsequent investment excess returns and the relationship to the level of R&D investment. They also analysed the variations in excess returns subsequent to the adjustment of book value (an outcome of capitalising R&D spending), to assess whether or not expensing R&D resulted in an under-valuation of such companies who undertook R&D. The results show that companies who invest in R&D experienced a visible level of positive excess returns, and out-performed counterpart shares who had not invested in R&D in the long-term. Moreover, no evidence of any relationship between the level of R&D investment and post-investment excess returns was found. The paper concluded that returns were higher for companies who focused less on R&D spending relative to companies with a high degree of focus toward R&D spending.

In general, studies done in BRICS nations have found some element of a positive relationship between R&D expenditure and firm value/performance, however, the results differ slightly relative to studies conducted in developed markets. For example, Naik, Narayanan and Padhi (2012) and Kim (2018) found that R&D investments have an inverted U-shaped relationship

with firm value, which does give evidence to a positive relationship such as in developed markets, however after increasing to a certain level due to increased R&D expenditure, firm value then begins to decrease. Studies done in South Africa provide evidence of a positive relationship between R&D and firm value, however they differ relative to those studies conducted in developed markets because they focus on R&D spending announcements and the capitalisation of R&D. Hence, where this study differs and adds a contribution to existing literature, is via a different measurement focus, looking at the expensed portion of R&D which appears on the income statement of BRICS firms.

2.6 Conclusion

The wealth of research which has been conducted in developed markets has documented a positive relationship between R&D expenditure and subsequent market performance, with few studies documenting no relationship. The small amount of literature conducted in developed markets, specifically the BRICS nations, has documented inverse U-relationships in China and India and positive relationship in South Africa. These findings suggest that it is achievable for investors to earn excess abnormal returns within the BRICS nations which the study tested in the following chapters.

3. Data and methodology

3.1 Introduction

As outlined in chapter 1, the purpose of this study is to examine the effect of *expected/total* and *unexpected* R&D increases reflected in the income statement on the long-term share price performance of firms in the BRICS countries. In this chapter, the null and alternative hypothesis are presented, followed by a discussion of the data and variables used. Lastly, the method used in this study, which draws from by Eberhart, Maxwell and Siddique (2004), Ali, Ciftci and Cready (2012) and Bhana (2013), is described.

3.2 Hypotheses

As outlined in the previous chapter, in an efficient market the stock price should respond fully and quickly to the information content of increased R&D expenditures. However, R&D expenditures create benefits that are uncertain and intangible. If investors under-react to the future benefits expected from the firm's R&D expenditure increase, then significant positive long-term abnormal stock returns in the periods following the R&D expenditures will be observed. On the other hand, if investors over-react to these future benefits, significant negative long-term abnormal stock returns in the periods following the R&D expenditure will be observed.

However, Eberhart, Maxwell and Siddique (2004) argue that because investors probably anticipate that firms will raise their R&D expenditure as they grow, positive long-term abnormal stock returns subsequent to increases in R&D expenditure are not expected. As such, it is the unexpected portion of R&D expenditures which stands the chance of not being fully and immediately incorporated into share prices upon the issue of a firm's financial statements. Thus, consistent with Eberhart, Maxwell and Siddique (2004), this study focuses on the impact of unexpected increases in R&D on long-term stock returns. The hypothesis thus tested is:

Hypothesis 1

H₀: There are no abnormal long-term stock returns following unexpected R&D expenditure increases for firms in the BRICS nations.

H₁: There are either positive or negative abnormal long-term stock returns following unexpected R&D expenditure increases for firms in the BRICS nations.

But, as highlighted in chapter 2, studies have also documented evidence of a positive relationship between stock returns following increases in total R&D in both the U.S. and

Europe (Toivanen, Stoneman & Bosworth, 2002; Chambers, Jennings & Thompson, 2002; Duqi, Mirti & Torluccio, 2011). Therefore, this study also analyses total/ expected R&D expenditure increases (referred to as R&D growth) with the following hypothesis:

Hypothesis 2

H₀: There are no abnormal long-term stock returns following R&D expenditure growth for firms in the BRICS nations.

H₁: There are either positive or negative abnormal long-term stock returns following R&D expenditure growth for firms in the BRICS nations.

3.3 Data

Data was collected for firms in each of the BRICS countries commencing from the respective date in which companies within the country were mandated to begin using IFRS up until 2020. Brazil's mandatory adoption was in 2010 (giving 10 years of data as the growth in R&D is computed from the first year of the financial statements being IFRS-compliant), Russia at the beginning of 2012 (eight years) and China in 2007 (13 years). The case for India and South Africa are not as straightforward as the other countries, this is due to the fact that there are two distinct periods regarding the use of IFRS where the adoption dates and mandated dates differ from one another, which is in contrast to Brazil, Russia and China.

India initially declared that it would begin using IFRS from 2011 onwards, which would have provided a nine year analysis. However, this was never actually enforced. A few years later the mandatory adoption of IFRS for listed companies was enforced, which comprised of two phases and excluded banks, insurance companies or any other financial institutions. The first phase was in 2016-2017 and applied to those companies who were listed or in the process of being listed with a net worth of five hundred million crores (Kulshrestha, 2019). The second phase applied to all other listed companies, excluding the financial institutions, not included in phase 1 from 1 April 2017 (Kulshrestha, 2019). Hence, for Indian firms using the IFRS condition there was only a three year analysis.

In South Africa, IFRS was formally adopted in 2005, however it was only legally enforced from the 1 May 2011 under the new Companies Act No. 71 of 2007. Therefore, May 2011 was used as the starting date for South African companies to be included in the analysis.

The study initially aimed to replicate a sample size similar to Eberhart, Maxwell and Siddique (2004), who analysed firms with increased R&D expenditure over a 50-year period between

1951 and 2000. However, BRICS economies do not have such long datasets, as is common in many U.S. asset pricing studies (e.g. Fama and French, 1993). Furthermore, U.S. studies on R&D expenditure have included much longer periods since U.S. companies only allow one way of dealing with R&D expenditure under GAAP by expensing it. In contrast, the BRICS countries have used differing accounting systems until the mandatory adoption of IFRS, which allows for both capitalising and expensing of R&D, in varying years after 2005. This contributes to the much smaller time period studied. The separation of adoption and mandatory enforcement dates in India and China also reduced the length available to analyse BRICS companies under IFRS. The studies on the BRICS countries reviewed in the previous chapter thus principally focused on periods prior to the adoption of IFRS in the respective countries, which further adds to the contribution of this study which focuses exclusively on the period after IFRS adoption.

The data was formed into three samples so as to analyse the BRICS nations collectively and individually as follows:

- (i) All BRICS nations from when all countries were mandated to use IFRS (with the exception of India), this being from 2012-2020 and forms the main sample of the study. Since India only began using IFRS in 2017, firms from this country were only included in this portfolio from the April 2017 onwards. As the growth in R&D is computed from the first year of the financial statements being IFRS-compliant, the analysis comprised 8 years.
- (ii) All BRICS countries from when the first nation began using IFRS, i.e. China from 2006-2020, with each country added to the sample from its year of enforcement of IFRS.
- (iii) BRICS countries individually, with each country examined separately from the date of IFRS enforcement. This yields an analysis for Brazil of 10 years, Russia 8 years, India 3 years, China 13 years and South Africa 9 years.

The firms included in the sample for each country were determined by membership of the most common indices representing each country's stock market. Typically these stocks are the most liquid on the exchange and therefore share prices are more likely to fully reflect new information, as per Chordia, Roll, and Subrahmanyam (2008) who found that liquidity

heightens arbitrage activity and subsequently improves market efficiency.¹ Hence, the Shanghai Shenzhen CSI 300 index was utilised for China, the RTS for Russia and S&P BSE 500 for India as these were accessible to the author. Moreover, the FTSE/JSE All Share index was used for South Africa and the Ibovespa Brasil Sao Paulo stock index (IBOV) was utilised for Brazil.

The IBOV is a gross total return index weighted by free float market capitalisation and is made up of the foremost liquid shares (more or less than 50) traded on the Sao Paulo stock exchange, denominated in Brazilian Real (BRN) (Bloomberg, 2021). The RTS Index is capitalisation-weighted and is amalgamated based on prices of the most liquid Russian shares of the biggest issuers accessible on the Moscow exchange. The number of constituents fluctuates but usually is never above 50. Although the number of shares is small, the index represents 85% of the total Russian market (RTS Indices, 2010). The index is calculated in real time and disseminated by the S&P Dow Jones. Hence, the share information was retrieved in U.S. dollars. The S&P BSE 500 index is free-float weighted, where the 500 shares represent approximately 93% of the entire market capitalisation of the BSE. Furthermore, it represents all 20 foremost sectors of the economy. It is denominated in Indian Rupees (INR) (Bloomberg, 2021).

The Shanghai Shenzhen CSI 300 Index is market capitalisation weighted index and comprises 300 shares listed on the Shanghai or Shenzhen stock exchange denominated in Chinese Yuan (CNY). The ALSI, denominated in Rands (ZAR), is a market capitalisation weighted index, where the constituents comprise approximately the top 99% of the total free-float market capitalisation of all listed companies on the JSE (Bloomberg, 2021).

For all countries, the chosen indices commenced prior to the start date of this study, the IBOV was founded in 1968, the RTS in 1995, the S&P BSE 500 in 1999, the CSI 300 index in 2004 and the FTSE/JSE Africa All Share index in 2002 (Bloomberg, 2021). From each index, the data includes listed, newly listed and delisted firms over the periods defined previously to ensure there was no survivorship bias. The total number of firms is displayed in the first column of Table 1.

¹ Furthermore, the Bloomberg data base required permission to view constituents of the Shenzhen, Moscow exchange (MOEX) and the Bombay stock exchange.

Table 1: Number of companies per country for unexpected increases in R&D

BRICS nations	Starting no. of firms	Final no. of firms (only condition 1)	Final no. of firms (both conditions)
Brazil	130	19	0
Russia	182	11	4
India	501	234	65
China	754	611	102
South Africa	312	34	7
Total	1879	909	178

Eberhart, Maxwell and Siddique (2004) and Bhana (2013) imposed the following two conditions when identifying firms with unexpected increases in R&D:

- (1) Only unexpected increases in R&D were included, which are defined when a firm's ratio of R&D to assets increases relative to the previous year. This is due to the fact that the market anticipates that companies will increase their R&D as they grow.
- (2) Only companies that have an economically significant R&D increase were included. This is quantified as firms that have as of the beginning of their R&D increase year, an R&D intensity (defined as the ratio of R&D to assets and R&D to sales) of at least 5%. In addition, the firm must increase its R&D (monetary value) by at least 5% and increase its ratio of R&D intensity by at least 5% (e.g. from 10% to 10.5%).

After imposing condition 1 the total number of firms left in the sample decreased from 1879 to 909 as displayed in Table 1, which still left a sizeable sample for the study. However, in countries such as Brazil, Russia and South Africa following the imposition of condition 1, the number of firms dropped markedly relative to their starting point, Brazil by 111 firms, Russia 171 and South Africa by 278 while for China and India the number of firms did decrease but not substantially (143 and 267).

When condition (2) was imposed, the total number of firms left in the sample decreased noticeably from 1879 to 178. There were zero Brazilian firms left in the sample, Russian and South African firms constituted only 4 and 7 firms of the total sample respectively, while India and China made up the remaining 167 firms. Therefore, relative to only condition 1 being imposed the sample size of both conditions being imposed is substantially small and would not have enabled the study to conduct a meaningful analysis of the BRICS countries. Hence, the study only imposed condition 1. Thus, the analysis examines all unexpected R&D increases.

In order to examine expected R&D increases, a second sample was constituted, which began from the same initial starting number of firms and thereafter imposed the condition similar to that of Duqi, Mirti and Torluccio (2011):

- (3) All firms who had increased their R&D expenditure (R&D growth was positive) were included.

The total number of firms within this sample and per country are displayed in Table 2.

Table 2: Number of companies per country for expected increases in R&D

BRICS nations	Starting no. of firms	Final no. of firms
Brazil	130	20
Russia	182	11
India	501	306
China	754	591
South Africa	312	42
Total	1879	970

From Table 2, the total number of firms left in the sample decreased from 1879 to 970, which is slightly larger than the 909 for the sample based on unexpected increases in R&D, as shown in Table 1, which is expected as firms are likely to increase their R&D expenditure as they grow. Following the imposition of condition 3, the number of firms for Brazil, Russia and South Africa dropped by 110, 171 and 270 respectively, which differed markedly from their starting points. For China and India, the number of firms decreased by 163 and 195 respectively, however there were still a large number of firms remaining within the sample.

3.4 Variable description for each company

The variables in Table 3, book value of total assets, and market capitalisation are measured as of the beginning of the sample firm's R&D increase financial year. The R&D intensity ratio (R&D to assets) is also measured as of the beginning of the R&D increase year. Stock returns (net of the U.S. one month T-bill rate i.e. the risk-free rate) are measured in calendar time for all sample firms following their R&D increases.

All financial statement data described in Table 3 is annual, while the price data is monthly (end of the month) and denominated in U.S. dollars, where all BRICS nations except Russia had to be converted, and includes dividends, to ensure consistency with the currency of the pricing factors (explained further in section 3.5.2), downloaded from the Kenneth French data library which were denominated in U.S. dollars. All stock prices, dividends and other firm information

was obtained from the Bloomberg database. Furthermore, returns were computed from the prices based on simple returns, Eberhart Maxwell and Siddique (2004) indicate that their paper used calendar time returns which is the arithmetic summation of returns where they used the average raw return of stocks in a calendar month.

Table 3: Variables used in determining portfolio formation and returns

Name	Description
Total assets	The total of all short and long-term assets.
Market capitalisation	Total shares outstanding multiplied by the current share price on each of the respective end of year dates.
R&D expenditure	The trailing 12 months' R&D expenditure calculated by adding the R&D expense from the four most recent quarters.
R&D/Assets	Ratio of R&D to assets used as a measure of R&D intensity
Increase in R&D percentage (%)	The year on year percentage change in R&D expenditure.
Monthly returns (less the risk free rate) (%)	Simple returns less the U.S. one month T-bill rate

Any stocks that had missing or no data were removed. Initially companies that had no R&D data for all of their respective beginning and end years were removed. Thereafter assets and market capitalisation were inspected for missing data and if there was missing data for all the respective years they too were removed. The starting number of firms (1879) is the total number of firms before this removal is performed.

3.5 Method

As highlighted previously, this study analysed the R&D increase (unexpected and total) reflected in the income statement and is grounded on accounting information, and not on R&D increase announcements as per Bhana (2013). Therefore, announcement period abnormal returns are not examined. The motivation for this is that announcement period abnormal returns do not reflect if the market is sluggish to assimilate the completeness of information from the R&D increase (Eberhart, Maxwell & Siddique, 2004). Instead, it is necessary to study long-term irregular share returns, as per Eberhart, Maxwell and Siddique (2004).

3.5.1 Portfolio formation

Following the extant literature, the first step to examining long-term stock returns was to form portfolios of stocks that experienced an unexpected increase in R&D (as per condition one)

and R&D growth (as per condition three). For this purpose, the financial year-end of the companies was important as the market must be informed of the accounting data before it can be used to explain stock returns (Fama & French, 1993).

Brazilian firms must file their financial statements by 31 March, which is within three months of their year-ends (Global Public Policy Committee, Extensions or other relief granted by regulators, 2020:2). Similarly, Russian companies must file their financial statements within three months of their year-end (Deloitte IAS Plus, 2021) while Indian firms are mandated to file their audited financial statements within 60 days of their financial year-end (Laskar, 2021). China's regulatory deadline is April 30th (Tham, 2020), which give Chinese firms four months from their December year-ends to publish their statements, and South African companies have to avail their financial statements within three months of their fiscal year-end according to Companies Act No. 71 of 2008.

Drawing from these mandatory release dates, stocks were included in the portfolio three months after the end of their fiscal year-end in which the firm experienced an unexpected R&D increase or had R&D growth. This three-month lag, similar to the four-month lag used by Chan, Lakonishok and Sougiannis (2001), was implemented to ensure that the market had been informed of the accounting data.

Moreover, cognisance had to be taken of the financial year-ends of companies in each country in the sample. All financial year-ends were extracted from Bloomberg and confirmed from the PWC Tax summaries website². As can be seen from Table 3, Brazil, Russia and China all had December year-ends which therefore meant that firms who had R&D growth or unexpected R&D increases in these countries could only be included in the portfolios from the 1st of April of the following year. India has a March year-end and therefore Indian firms were only included in the portfolio from the 1st of July of that same year. South African firms do not have a universal financial year-end and therefore the financial year-end of each firm was obtained, and the stock included in the portfolio three months after the financial year-end.

² <https://taxsummaries.pwc.com/search#q=financial%20year%20ends>

Table 4: BRICS nations financial year-ends

Country	Financial year-end	Included in the portfolio from
Brazil	December	1st April
Russia	December	1st April
India	March	1st July
China	December	1st April
South Africa	Mixed	Case-by-case basis

Once a company had been included in the portfolio, it remained in the portfolio for a 36-month period (Bhana, 2013). If the firm experienced further R&D growth or an had an unexpected increase in R&D in the year thereafter, it would remain in the portfolio for a further 12 months so as to maintain the 36-month holding period following a consecutive increase. Majority of the studies conducted in developed markets outlined in Chapter 2 have a holding period of five years or longer, while Bhana (2013) uses a 36-month holding period for South African firms. This study employs the same holding period in the analysis of similar emerging markets within BRICS as opposed to the U.S. or U.K. Furthermore, measuring returns over a 36-month period gives the study a measure of long-term abnormal stock returns as opposed to only one month ahead returns and the time period of data for this study is similar to studies done in developed markets.

Studies which have estimated standalone stock betas from a regression are said to be susceptible to the ‘error-in-the-variables’ problem. Miller and Scholes (1972) found that this problem resulted in the slope coefficient being downward biased and the intercept being upward biased. Moreover, if the true value of beta is positively correlated with the residual variance of the stock, the error-in-the-variables issue may result in residual risk becoming a crucial determining factor of returns. Black, Jensen and Scholes (1972) and Fama and MacBeth (1973) suggested clustering stocks into portfolios in order to mitigate and nullify the error problem, as the measurement error would become relatively inconsequential since individual beta errors would be neutralised within a portfolio. On the other hand, grouping stocks into portfolios causes issues such as reducing the range of beta values (Fama & French, 2004) and creating larger standard errors of coefficients in cross-sectional regressions due to the decreased information (Ang, Liu, & Schwarz, 2010). Moreover, utilising portfolios of stocks can produce pricing errors of individual shares, which come about because of a poorly specified model, cancelling out one another (Roll, 1977; Grauer & Janmaat, 2004). Despite these

downsides to using portfolios, it is common practice to use portfolios in the testing of assets prices rather than using individual shares to avoid the error in the variables issues described above (Kan, 1999; Ang, Liu, & Schwarz, 2010).

Use of calendar-time returns and long sample periods as per Eberhart, Maxwell and Siddique (2004) also address any possible concern that results would be driven by short time periods where firms that have increased their R&D in a once off situation or do so irregularly, end up performing abnormally well. Following Eberhart, Maxwell and Siddique (2004), value weighted and equal weighted portfolios were computed, despite concerns that these methods are biased in favour of the EMH.

3.5.2 Models used in the study

To determine abnormal returns, the CAPM is usually used as defined in equation (1), which identifies abnormal returns, captured by alpha, as returns which cannot be explained by systematic risk.

$$R_{pt} - R_f = \alpha + b(R_{mt} - R_f) + e_{pt} \quad (1)$$

In his test of the EMH and analysis of performance of common shares in relation to their price-earnings (P/E) ratios, Basu (1977) found that when common shares were organised by P/E ratios, future returns on high P/E shares were larger relative to ones predicted by the CAPM. Moreover, Banz (1981) organised shares based on market capitalisation and found that mean returns on small (large) shares were greater (lower) than ones forecasted by CAPM, therefore supporting a size effect. Bhandari (1988) established that firms with high debt-equity ratios earned returns that were far greater relative to their market betas. Furthermore, succeeding studies found evidence that shares with high book-market equity ratios earned greater average returns that were not reflected by their respective betas (Statman, 1980; Rosenberg, Reid & Lanstein, 1985). Fama and French (1992) confirmed the findings of prior studies and undertook a more comprehensive analysis. They found that various characteristics of a company such as size, earnings-price, debt-equity and book-to-market add to the explanation of predicted stock returns offered by market beta.

As a consequence of these studies showing that the CAPM cannot sufficiently explain returns especially the returns to small and value stocks, Fama and French (1993) devised an alternative three-factor model which is an expansion of the CAPM. The model incorporates the empirical findings that small companies outperform large companies, and value companies earn higher

returns than growth companies on a risk-adjusted basis. Fama and French (1993) revealed that the model could explain more than 90% of diversified portfolios' returns. Fama and French (1998) also found that price ratios that created difficulties for CAPM using U.S. data were also prevalent in stock markets outside the U.S. including emerging markets, and hence can be used in this study of the BRICS nations. Thus, by using the three factor model rather than the CAPM, it ensures that any outperformance is not due to small firms or value stocks (or systematic risk) but due to R&D increases.

The Fama and French three-factor model was used to determine long-term abnormal stock returns as follows:

$$R_{pt} - R_f = \alpha + b(R_{mt} - R_f) + sSMB_t + hHML_t + e_{pt} \quad (2)$$

where R_{pt} is the returns on the portfolio comprising stocks with unexpected R&D increases and then growth in R&D in calendar month t , R_f is represented by the U.S. one month T-bill rate retrieved from the Kenneth French data library, R_{mt} is the market proxy which is the return on the emerging markets index value-weight market portfolio, SMB_t is the return on a portfolio of small stocks minus the return on a portfolio of large stocks, and HML_t is the return on a portfolio of stocks with high book-to-market ratios minus the return on a portfolio of stocks with low book-to-market ratios. The construction of the SMB and HML factors are discussed in the following section.

However, Carhart (1997) showed that the three-factor model cannot explain the momentum anomaly and therefore proposed an extension to the model to account for this pricing phenomenon. This is known as the Carhart (1997) four-factor model. Therefore, this model was also used to account for momentum i.e. outperformance may be due to the fact that winners remain winners and losers remain losers. As such, the following model was also estimated:

$$R_{pt} - R_f = \alpha + b(R_{mt} - R_f) + sSMB_t + hHML_t + mUMD_t + e_{pt} \quad (3)$$

where UMD is the return on high momentum stocks minus the return on low momentum stocks.

The intercept (α) in equations (2) and (3) is the abnormal return measure. It was examined for significance to determine if unexpected R&D and R&D growth increase firms earn more than predicted based on the asset pricing model i.e. if alpha significant then this would indicate that the EMH does not hold. The sign would then indicate whether there is underreaction (positive)

or overreaction (negative). Through the examination of the significance of alpha the study was able to test the hypotheses outlined in section 3.2.

In estimating these two equations, two statistical phenomena were observed, namely autocorrelation and heteroskedasticity. Heteroskedasticity arises when the variance of the residuals is not uniform across all observations within a sample. In the presence of heteroskedasticity, the coefficients are not affected, however the standard errors likely become unreliable estimates and the test statistics are no longer valid (Wooldridge, Wadud, & Lye, 2016:293). Likewise, autocorrelation arises when the error term in a period is related to the error term in another prior period. The coefficients are still unbiased in the presence of autocorrelation, however, the standard errors are unreliable (Wooldridge, Wadud, & Lye, 2016:409). In light of the problems created by autocorrelation and heteroskedasticity, the standard errors in equations (2) and (3) are adjusted for heteroskedasticity and autocorrelation using HAC adjusted standard errors on the EViews statistical package.

3.5.3 Factor construction

Considering that all BRICS nations are emerging markets, the Fama and French emerging market three factors and Carhart momentum factor. were collected from the Kenneth French data library³. Furthermore, the factors from the Kenneth French library are well used in empirical studies conducted in developed markets (Eberhart, Maxwell & Siddique, 2004; Kim, 2010; McShane et al., 2012) and developing markets (Brockman et al., 2009; Pollard, Sherwood & Klobus, 2018; Sehrawat et al., 2020).

The emerging market nations from which all the factor data is comprised include: Argentina, Brazil, Chile, China, Colombia, Czech Republic, Egypt, Greece, Hungary, India, Indonesia, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Qatar, Russia, Saudi Arabia, South Africa, South Korea, Taiwan, Thailand, Turkey and United Arab Emirates. The fact that all of the BRICS countries are included in this sample shows the relevance of this set of portfolios.

All factor returns were in U.S. dollars and included dividends and capital gains. The returns were not continuously compounded. These same pricing factors were used for all the samples (e.g. even the country-specific analyses) for the purposes of consistency.

The Fama and French three factors were constructed by using six value-weight portfolios formed on size and book-to-market (B/M) ratio, another six created on size and operating

³ http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

profitability (OP), and another six grouped on size and investment (INV). To construct the SMB and HML factors, stocks in a nation are organised into two market capitalisation (small and big), three book-to-market equity (value, neutral and growth), three OP (robust, neutral and weak) and INV (conservative, neutral and aggressive) groups at the end of each June month. Big shares are those in the top 90% of market capitalisation, and small shares comprise the lowest 10%. The B/M, OP and INV cut-off points are the 30th and 70th percentiles of corresponding ratios for the big shares of the country. Hence the following eighteen portfolios are created: S/V, S/N, S/G, B/V, B/N, B/G (where B/G, for example, comprises large stocks with growing book-to-market equity), S/R, S/N, S/W, B/R, B/N, B/W (where S/R comprises small stocks with robust operating profit) and S/C, S/N, S/A, B/C, B/N, B/A (where B/A comprises large stocks that have aggressive investment) (French, 2021).

SMB is calculated by taking the difference in the mean returns between the small share portfolios (S/V, S/N, S/G, S/R, S/N, S/W, S/C, S/N and S/A) and the corresponding returns of big share portfolios (B/V, B/N, B/G, B/R, B/N, B/W, B/C, B/N And B/A). Similarly, HML is calculated by taking the difference of simple mean returns between the S/V and B/V portfolios and mean returns on the S/G and B/G portfolios (French, 2021). The SMB and HML factors are value weighted, which is most common in research papers. Furthermore, the data library could only provide access to value weighted factors for the three-factor model of emerging markets, however this approach of using the value weighted factors even when equal weighted portfolios are used as the test assets is consistent with the methodology used by Eberhart, Maxwell and Siddique (2004).

The expected return on the market less the risk free rate for July of each year to June of the following year included all shares for which the data library had market equity data for June of each year of the emerging markets.

To form the momentum factor (UMD), stocks are organised according to size and momentum on a monthly basis. For portfolios formed at the end of the previous month, the lagged momentum yield represented a share's collective yield for the previous ten months. The momentum cut-off points are the 30th and 70th percentiles of the lagged momentum yields of the big shares of the nation. The independent 2x3 sorts on size and momentum produce six value weighted portfolios (SL, SN, SW, BL, BN and BW) where S and B indicate small and big and L, N and W indicate losers, neutral and winners (bottom 30%, middle 40% and top

30%). UMD is calculated by taking the mean equal weighted returns of the winner portfolios less the mean return of the two loser portfolios (French, 2021).

3.6 Conclusion

This chapter outlined the data that is used in this study, detailed the way in which firms were selected for the BRICS countries as well as the variables and conditions imposed in the formation of the samples and subsequent portfolios. Lastly, it described the two models, namely the Fama and French (1993) three factor model and Carhart (1997) four factor model used to identify abnormal returns. The results of the analysis are presented in the next chapter.

4. Empirical results

4.1 Introduction

This chapter presents the results of the tests to determine the impact of unexpected and total R&D increases on the long-term stock returns of firms in the BRICS countries. Firstly, the results of the main sample of the study, the collective BRICS country results from 2012-2020 for both R&D growth and an unexpected increase in R&D, are examined. The analysis of the second sample, which commences when the first country began using IFRS i.e. China, follows thereafter, and lastly the individual country results, which were used as robustness tests, are assessed. The chapter concludes by comparing all other samples to the main sample and the findings relative to studies done in developed and developing markets, specifically within BRICS.

4.2 Descriptive Statistics

The descriptive statistics for the sample and the portfolios formed are presented in Table 5. The average size of firms in the sample is \$99 284 million but there was substantial variation signalling that the sample comprises both small and large firms. With respect to R&D/assets the average increase was 2.14% which suggests that overall firms in BRICS countries had unexpectedly increased their R&D, however there was substantial variance which shows there may not have been consistency in such increases. On average, BRICS firms increased their R&D by \$71 year on year, which is nearly double the \$37.884 mean increase in Eberhart, Maxwell and Siddique's (2004) paper. For both expected and unexpected increases in R&D, the value weighted portfolio returns were larger. The descriptive statistics for BRICS nations from 2007 (Table A1) and individually (Table A2) are contained in the Appendix.

Table 5: BRICS 2012 descriptive statistics

Statistic	Mean	Standard deviation
Total assets (\$MM)	99284.6803	669611.6005
Market capitalisation (\$MM)	73044.0062	316640.0113
Unexpected R&D increases:		
R&D/assets	2.1358%	18.2837%
Average monthly return:		
Value weighted	4.8147%	19.4608%
Equal weighted	1.0751%	7.2787%
R&D growth:		
Dollar increase in R&D	70.7828	782.3812
Average monthly return:		
Value weighted	4.8211%	19.5055%
Equal weighted	1.0670%	7.1946%

4.3 Collective BRICS country results beginning 2012

The results for the BRICS countries collectively from 2012 are presented in Table 6 and analysed in the sub-sections that follow.

Table 6: Collective BRICS country results from 2012

Model	Weight	α	b	s	h	m	R^2 (\bar{R}^2)
<i>Panel A: BRICS from 2012 firms with an unexpected R&D increase 2012-2020</i>							
Fama and French (1993)	Value	0.0275* (0.0758)	3.1085*** (0.0000)	2.7972*** (0.0008)	-0.4154 (0.5607)		0.5296 (0.5161)
	Equal	0.0043 (0.4970)	0.9232*** (0.0000)	1.5604*** (0.0007)	0.1032 (0.6253)		0.3980 (0.3808)
Carhart (1997)	Value	0.0231 (0.2190)	3.1476*** (0.0000)	2.7645*** (0.0009)	-0.1231 (0.8805)	0.4196 (0.6663)	0.5312 (0.5132)
	Equal	0.0055 (0.4448)	0.9127*** (0.0000)	1.5691*** (0.0007)	0.0251 (0.9323)	-0.1121 (0.6792)	0.3989 (0.3758)
<i>Panel B: BRICS firms with positive R&D growth in any year between 2012-2020</i>							
Fama and French (1993)	Value	0.0270* (0.0701)	3.2085*** (0.0000)	2.6120*** (0.0006)	-0.7695 (0.3135)		0.5425 (0.5294)
	Equal	0.0042 (0.4915)	0.92740*** (0.0000)	1.6120*** (0.0004)	0.0815 (0.6864)		0.4118 (0.3950)
Carhart (1997)	Value	0.0226 (0.2295)	3.2473*** (0.0000)	2.5796*** (0.0007)	-0.4795 (0.5684)	0.4164 (0.6930)	0.5441 (0.5266)
	Equal	0.0049 (0.4857)	0.9218*** (0.0000)	1.6167*** (0.0004)	0.0397 (0.8901)	-0.0601 (0.8271)	0.4121 (0.3895)

Note: p-values indicated in brackets: *p<0.1 – significant at 10% level, **p<0.05 – significant at 5% level, ***p<0.001 – significant at 1% level.

4.3.1 BRICS unexpected R&D increase (Panel A)

The value weighted portfolio used in the Fama and French three factor model (Panel A) had a large and positive (3.1085) market beta which was statistically significant at the 1% level with a p-value of zero. This suggests that the portfolio had very high systematic risk and that the excess market return had significant value for explaining the excess return of these BRICS stocks. The SMB factor was positive (2.7972) and significant at the 1% level with a p-value of 0.0008 which indicated that the portfolio had greater sensitivity to smaller stocks and likely comprised of a greater number of smaller stocks. The HML factor was insignificant and did not explain returns. The alpha was positive (2.75%) and statistically significant at the 10% level with a p-value of 0.0758. Therefore, it can be concluded that this portfolio comprising stocks with unexpected R&D increases does earn abnormal returns in the long run with a considerable annual return of 33%.

The value weighted portfolio under the Carhart four factor model similarly had large, positive and statistically significant coefficients on the excess market return and SML factors, with p-

values of zero and 0.0009, respectively. These findings suggest that the portfolio has high systematic risk and likely comprised of smaller stocks. The momentum factor, along with the value factor, were insignificant. The intercept term (2.31%) was also statistically insignificant; therefore, it can be concluded that this portfolio did not earn abnormal returns in the long run.

The equal weighted portfolio in both the Fama and French three factor model and Carhart four factor model had a significant market beta but was below one in magnitude indicating that the portfolio has low systematic risk. Moreover, the SMB factors were both positive (1.5604 and 1.5691) and statistically significant at the 1% level, which suggests that the portfolio had a greater sensitivity toward smaller stocks. The equal weighted portfolios had statistically insignificant alphas, therefore the null hypothesis (hypothesis 1) cannot be rejected.

The R-squared and adjusted R-squared values for these models ranged between 37.58% and 54.41%. The results indicated that in most cases the factors explained nearly half or over half of the variation in the monthly returns within BRICS companies following an unexpected increase in R&D expenditure.

Only the value weighted portfolio in the Fama and French model had displayed positive and significant alphas, therefore there is some evidence that the null can be rejected and concluded that firms who have an unexpected increase in R&D experienced positive abnormal returns in this case, however there is also some evidence that the null cannot be rejected.

4.3.2 R&D growth (Panel B)

The value weighted portfolio used in the Fama and French three factor model (Panel B) revealed that all of the risk factors except for the HML factor were statistically significant. The market beta was large and positive (3.2085) and statistically significant at the 1% level with a p-value of zero, which suggests that this portfolio had very high systematic risk and that the excess market return had significant value for explaining the excess return of these BRICS stocks. The SMB factor was positive (2.6120) and significant at the 1% level which indicates that this portfolio has greater sensitivity to smaller stocks meaning that it likely comprises more smaller stocks. The R-squared and adjusted R-squared estimates revealed that the factors could explain 54.25% and 52.94% of the monthly returns in the BRICS companies, respectively. Moreover, alpha was positive (2.7%) and significant at the 10% level with a p-value of 0.0701, therefore it can be concluded that this portfolio of BRICS firms does earn abnormal returns in

the long run. Moreover, it suggests that this portfolio could make an annual return of 32.4% (monthly return of 2.7%) which is particularly substantial.

The equal weighted portfolio under the Fama and French three factor model (Panel B) had positive coefficient on the market (0.9274) and SMB (1.6120) factors which were both significant at the 1% level, indicating that the portfolio is more sensitive to small stocks and has low systematic risk. The HML factor does not explain returns for this portfolio. Moreover, the R-squared and adjusted R-squared revealed that the factors could explain 41.18% and 39.50% of the monthly returns, respectively. The alpha was statistically insignificant, therefore it can be concluded that this equal weighted portfolio of BRICS firms, does not earn abnormal returns.

The value weighted portfolio used in the Carhart four factor model had a large and positive market beta (3.2473) and SMB (2.5796) risk factor which were both statistically significant at the 1% level. The momentum and HML factors were statistically insignificant and thus did not explain returns. Furthermore, R-squared and adjusted R-squared values were just over 50% suggesting that the factors could explain over half of the monthly returns. The intercept term (alpha) was positive (2.26%) but insignificant, therefore it can be concluded that this portfolio of BRICS firms with R&D growth did not earn abnormal returns in the long run.

Since the alpha was significant in the Fama and French model but not in the Carhart model, it means that the addition of the UMD factor can explain the abnormal returns earned under the Fama and French model. This may suggest that the abnormal returns earned under the Fama and French model are actually attributable to momentum in stock returns i.e. that the stocks that have performed well (poorly) in the past continue to perform well (poorly) rather than the abnormal return being attributable to the firm's R&D expenditure growth.

The equal weighed portfolio in the Carhart four factor model had a market beta lower than one (0.9218) which was statistically significant at the 1% level, which indicated that the portfolio had relatively low systematic risk. Similarly, the SMB factor was positive (1.6167) and statistically significant at the 1% level with a p-value equal to 0.0004. The momentum and HML factors were statistically insignificant and did not explain returns. The R-squared and adjusted R-squared indicated that the factors explained 41.21% and 38.95% of the monthly returns. The alpha term was again statistically insignificant, therefore for this equal weighted

portfolio of BRICS firms, the null hypothesis that firms with R&D growth do earn abnormal returns could not be rejected.

Overall, in three of the four models – the alpha was insignificant suggesting no abnormal returns for firms with R&D growth. Hence the null hypothesis (hypothesis two) could not be rejected.

4.4 Collective BRICS country results from 2007

The results for the BRICS countries collectively from 2007 are presented in Table 7 and analysed in the sub-sections that follow.

Table 7: Collective BRICS country results from 2007

Model	Weight	α	b	s	h	m	R^2 (\bar{R}^2)
<i>Panel A: BRICS from 2007 firms with an unexpected R&D increase 2007-2020</i>							
Fama and French (1993)	Value	0.0286* (0.0834)	0.8316* (0.0973)	1.1859 (0.2378)	0.9948 (0.3616)		0.1796 (0.1617)
	Equal	0.0054 (0.3386)	0.3687** (0.0253)	0.8392* (0.0526)	0.4374 (0.2171)		0.1875 (0.1699)
Carhart (1997)	Value	0.0258 (0.1265)	0.8608 (0.1034)	1.1805 (0.2365)	1.2019 (0.2821)	0.3146 (0.6657)	0.1816 (0.1577)
	Equal	0.0051 (0.3881)	0.3718** (0.0314)	0.8386* (0.0535)	0.4592 (0.1912)	0.0331 (0.8763)	0.1877 (0.1639)
<i>Panel B: BRICS firms with positive R&D growth in any year between 2007-2020</i>							
Fama and French (1993)	Value	0.0294* (0.0789)	0.8441 (0.1116)	1.0236 (0.2911)	0.7586 (0.5195)		0.1716 (0.1536)
	Equal	0.0061 (0.2873)	0.4245** (0.0446)	0.6572 (0.2399)	0.5384 (0.1593)		0.2133 (0.1962)
Carhart (1997)	Value	0.0267 (0.1191)	0.8727 (0.1180)	1.0183 (0.2902)	0.9613 (0.4206)	0.3079 (0.6811)	0.1736 (0.1494)
	Equal	0.0080 (0.18570)	0.4050* (0.0556)	0.6608 (0.2443)	0.4002 (0.2817)	-0.2100 (0.3386)	0.2174 (0.1945)

Note: p-values indicated in brackets: *p<0.1 – significant at 10% level, **p<0.05 – significant at 5% level, ***p<0.001 – significant at 1% level.

4.4.1 Unexpected R&D increases (Panel A)

Overall the trend within this sample is low R-squared and adjusted R-squared values ranging from 15.77%-18.75% which suggests that additional risk factors are needed to better explain returns. These are much lower than seen in the main sample commencing from 2012.

The value weighted portfolio in the Fama and French three factor model had a positive market beta (0.8316) which was significant at the 10% level with a p-value of 0.0973. None of the other risk factors were significant. The alpha term was positive (2.86%) and statistically significant at the 10% level with a p-value of 0.0834. Thus, this portfolio did earn abnormal returns. On the other hand, the value weighted Carhart four factor model displayed no significant risk factors and its intercept term was insignificant, which suggests that the portfolio did not earn abnormal returns and the null hypothesis cannot be rejected.

The equal weighted portfolios in both the Fama and French and Carhart models displayed similar findings. The market betas were positive and significant at the 5% level with p-values of 0.0253 and 0.0314, respectively. Furthermore, both portfolios had positive and significant SMB factors which were significant at the 10% level with p-value of 0.0526 and 0.0535 respectively and likely comprise smaller stocks, which is similar to prior results. None of the other risk factors were statistically significant. Similarly, under both models, the portfolio alphas were not statistically significant and therefore it can be concluded that these portfolios did not earn abnormal returns and therefore the null hypothesis (Hypothesis 1) cannot be rejected.

4.4.2 R&D growth (Panel B)

All risk factors for the value weighted portfolios for both models were statistically insignificant and did not explain returns. Therefore, it can be concluded that additional factors are needed to further explain the monthly returns within these portfolios. The conclusion is consistent with the R-squared and adjusted R-squared estimates, which ranged from 14.94%-17.36%.

The only difference between the equal and value weighted portfolios within both models for R&D growth, was that the equal weighted portfolios had positive HML factors (0.4245 and 0.4050) which were statistically significant at the 5% and 10% levels respectively. Therefore, these portfolios were more sensitive to smaller stocks and likely comprised of smaller stocks. All other risk factors in every portfolio within both models were insignificant and did not explain the monthly returns. Only the alpha of the value weighted portfolio in the Fama and French three factor model was positive (2.94%) and significant at the 10% level, which suggests that in the long-term this portfolio did earn abnormal returns with an annual return of 35.28%.

On the other hand, all equal weighted portfolios in both models had intercept terms which were statistically insignificant and could be attributed to very large variability in the data. Therefore it can be concluded that all equal weighted portfolio of BRICS nations did not earn abnormal returns associated with an increase in R&D. This is probably due to the fact that only India and China had positive alphas when regressed by themselves (Section 4.5 Table 8, Panels E-H), therefore by equal weighting these portfolios the effect/weighting of China had been removed, as discussed further in the proceeding section. Moreover, all portfolios had low R-squared and adjusted R-squared values, which suggests that the factors explained a small amount of the monthly returns.

For this sample of BRICS nations taken from 2007, R&D growth and unexpected R&D increases only revealed one portfolio each where the alpha term was positive in which both appeared in the value weighted portfolios in the Fama and French three factor model. These findings suggest that there is evidence of investor underreaction to increases in R&D expenditure as discussed in Section 4.5. Furthermore, the fact that the positive alphas disappears when the Carhart model is used is also interesting as it may suggest some sort of momentum explanation in the value weighted portfolios.

4.5 Individual BRICS country results

The results for the BRICS countries individually are presented in Table 8.

Table 8: Individual BRICS country results

Model	Weight	α	b	s	h	m	R^2 (\bar{R}^2)
<i>Panel A: Brazilian firms with unexpected R&D growth in any year between 2010-2020</i>							
Fama and French (1993)	Value	0.0044 (0.3733)	0.0371 (0.7094)	-0.4488 (0.1641)	0.3683 (0.2212)		0.0330 (0.0043)
	Equal	0.0021 (0.7979)	0.1242 (0.4512)	-0.6837 (0.1836)	0.4923 (0.2681)		0.0349 (0.0062)
Carhart (1997)	Value	0.0070 (0.2762)	0.0207 (0.8471)	-0.4272 (0.1716)	0.2043 (0.5487)	-0.2541 (0.4498)	0.0384 (0.0000)
	Equal	0.0046 (0.6447)	0.1088 (0.5413)	-0.6632 (0.1858)	0.3366 (0.4813)	-0.2412 (0.6336)	0.0369 (-0.0016)
<i>Panel B: Brazilian firms with positive R&D growth in any year between 2010-2020</i>							
Fama and French (1993)	Value	0.0026 (0.5737)	0.0173 (0.8608)	-0.3920 (0.1875)	0.3834 (0.1906)		0.0310 (0.0023)
	Equal	0.0002 (0.9800)	0.0834 (0.6440)	-0.6976 (0.1717)	0.5679 (0.2341)		0.0328 (0.0041)
Carhart (1997)	Value	0.0057 (0.3429)	-0.0051 (0.9829)	-3.0051 (0.2029)	0.1939 (0.5429)	-2.0051 (0.3429)	0.0389 (0.0005)
	Equal	0.0029 (0.7566)	0.0665 (0.7296)	-0.6752 (0.1790)	0.3981 (0.4205)	-0.2631 (0.5877)	0.0351 (-0.0035)
<i>Panel C: Russian firms with an unexpected R&D increase 2012-2020</i>							
Fama and French (1993)	Value	0.0058 (0.5484)	0.2474 (0.1232)	0.4792 (0.4957)	-0.6893* (0.0578)		0.0372 (-0.0002)
	Equal	0.0132 (0.1235)	-0.0379 (0.7806)	0.5788 (0.4201)	-0.8441** (0.0167)		0.0614 (0.0248)
Carhart (1997)	Value	0.0033 (0.7829)	0.2649 (0.1176)	0.4571 (0.5147)	-0.5365 (0.2542)	0.2674 (0.6447)	0.0400 (-0.0105)
	Equal	0.0111 (0.2846)	-0.0231 (0.8733)	0.5600 (0.4330)	-0.7175 (0.0915)	0.2266 (0.5671)	0.0635 (0.0142)
<i>Panel D: Russian firms with an positive R&D increase 2012-2020</i>							
Fama and French (1993)	Value	0.0055 (0.2918)	0.0392 (0.7446)	-0.3159 (0.4895)	0.3738 (0.2602)		0.0272 (-0.0056)
	Equal	0.0081 (0.3507)	-0.0484 (0.7572)	-0.9226 (0.1818)	0.9042* (0.0590)		0.0603 (0.0286)
Carhart (1997)	Value	0.0070 (0.3528)	0.0289 (0.8039)	-0.3049 (0.4999)	0.2643 (0.4600)	-0.1712 (0.6819)	0.0296 (-0.0145)
	Equal	0.0087 (0.3544)	-0.0527 (0.7537)	-0.9180 (0.1759)	0.8590 (0.0639)*	-0.0707 (0.8957)	0.0605 (0.0178)

Model	Weight	α	b	s	h	m	R^2 (\bar{R}^2)
<i>Panel E: Indian firms with an unexpected R&D increase 2012-2020</i>							
Fama and French (1993)	Value	0.0012 (0.7071)	0.4683*** (0.0000)	0.8595** (0.0137)	0.1344 (0.3229)		0.6029 (0.5588)
	Equal	0.0117* (0.0729)	0.9193*** (0.0000)	2.9173*** (0.0000)	0.4938** (0.0150)		0.7319 (0.7021)
Carhart (1997)	Value	-0.0009 (0.7672)	0.4900*** (0.0000)	0.8405** (0.0127)	0.2711 (0.2414)	0.1967 (0.2250)	0.6111 (0.5512)
	Equal	0.0042 (0.5186)	0.9953*** (0.0000)	2.8508*** (0.0000)	0.9719** (0.0190)	0.6882* (0.0744)	0.7538 (0.7160)
<i>Panel F: Indian firms with an unexpected R&D increase 2012-2020</i>							
Fama and French (1993)	Value	0.0043 (0.2937)	0.6155*** (0.0000)	1.0744*** (0.0098)	0.0929 (0.6402)		0.5803 (0.5337)
	Equal	0.0126* (0.0612)	0.9146*** (0.0000)	2.9913*** (0.0000)	0.5037** (0.0188)		0.7280 (0.6978)
Carhart (1997)	Value	0.0005 (0.9139)	0.6540*** (0.0000)	1.0408*** (0.0081)	0.3349 (0.2982)	0.3484 (0.1442)	0.5954 (0.5331)
	Equal	0.0049 (0.4732)	0.9924*** (0.0000)	2.9233*** (0.0000)	0.9926** (0.0174)	0.7037* (0.0725)	0.7505 (0.7121)
<i>Panel G: Chinese firms with an unexpected R&D increase 2012-2020</i>							
Fama and French (1993)	Value	0.0086* (0.0843)	0.0671* (0.0567)	-0.2773 (0.2572)	0.0494 (0.8457)		0.0216 (0.0002)
	Equal	0.0075 (0.2521)	0.1781*** (0.0001)	-0.2382 (0.5125)	-0.0095 (0.9776)		0.0334 (0.0123)
Carhart (1997)	Value	0.0084* (0.0947)	0.0694* (0.0653)	-0.2781 (0.2562)	0.0641 (0.8114)	0.0237 (0.8222)	0.0218 (-0.0070)
	Equal	0.0086 (0.1992)	0.1658*** (0.0036)	-0.2344 (0.5204)	-0.0895 (0.8179)	-0.1286 (0.4816)	0.0350 (0.0066)
<i>Panel H: Chinese firms with an unexpected R&D increase 2012-2020</i>							
Fama and French (1993)	Value	0.0089* (0.0619)	0.0541 (0.1795)	-0.2374 (0.2951)	0.0320 (0.9001)		0.0165 (-0.0050)
	Equal	0.0090 (0.1686)	0.1948*** (0.0011)	0.0125 (0.9759)	-0.1582 (0.6917)		0.0288 (0.0075)
Carhart (1997)	Value	0.0087* (0.0689)	0.0559 (0.1910)	-0.2380 (0.2941)	0.0437 (0.8680)	0.0189 (0.8524)	0.0166 (-0.0123)
	Equal	0.0125* (0.0642)	0.1548** (0.0209)	0.0249 (0.9506)	-0.4171 (0.3819)	-0.4166* (0.0702)	0.0433 (0.0152)

Model	Weight	α	b	s	h	m	R^2 (\bar{R}^2)
<i>Panel I: South African firms with an unexpected R&D increase 2012-2020</i>							
Fama and French (1993)	Value	-0.0041** (0.0184)	0.3016*** (0.0000)	-0.0393 (0.5863)	0.0372 (0.7905)		0.3461 (0.3263)
	Equal	-0.0079* (0.0933)	0.8336*** (0.0000)	-0.0139 (0.9642)	0.8208*** (0.0097)		0.4996 (0.4844)
Carhart (1997)	Value	-0.0025 (0.1644)	0.2935*** (0.0000)	-0.0289 (0.6813)	-0.0700 (0.6655)	-0.1555* (0.0642)	0.3594 (0.3332)
	Equal	-0.0008 (0.8836)	0.7977 (0.0000)	0.0323 (0.9125)	0.3467 (0.3000)	-0.6879** (0.0196)	0.5336 (0.5146)
<i>Panel J: South African firms with an unexpected R&D increase 2012-2020</i>							
Fama and French (1993)	Value	-0.0064** (0.0115)	0.5553*** (0.0000)	-0.0359 (0.8121)	0.0105 (0.9638)		0.4851 (0.4690)
	Equal	-0.0111** (0.0328)	0.9487*** (0.0000)	0.0939 (0.7351)	0.8977 (0.0038)		0.5710 (0.5576)
Carhart (1997)	Value	-0.0067*** (0.0079)	0.5556*** (0.0000)	-0.0344 (0.8176)	0.014710 (0.9502)	0.0337 (0.7226)	0.4855 (0.4639)
	Equal	-0.0103* (0.0704)	0.9478*** (0.0000)	0.0901 (0.7482)	0.8873*** (0.0029)	-0.0830 (0.6928)	0.5717 (0.5536)

Note: p-values indicated in brackets: *p<0.1 – significant at 10% level, **p<0.05 – significant at 5% level, ***p<0.001 – significant at 1% level.

For the portfolios comprising Brazilian firms, both equal- and value weighted, there were no statistically significant risk factors for any of the models which suggests that additional factors are needed to explain monthly returns of Brazilian firms who had both positive R&D growth and unexpected R&D increases between 2010-2020, as shown in Panel A of Table 8.

Similar to Brazil, the R&D growth portfolio of Russian firms (Panels C-D) mostly displayed insignificant risk factors. However, for the equal weighted portfolio in both models, the HML factor was positive 0.9042 (Fama and French) and 0.8590 (Carhart) and significant at the 10% level, which means that the portfolio returns were more sensitive to value (high B/M ratios) stocks and are likely comprised of such value stocks. In contrast to the R&D growth portfolios, the unexpected R&D increase equal and value weighted portfolios (Panel C), for the Fama and French three factor model displayed negative (-0.6893 and -0.8441) HML factors at the 10% and 5% levels respectively. Therefore, these portfolios had a greater sensitivity toward growth stocks (low B/M ratios) and likely comprised of such growth stocks.

The analysis of Indian firms revealed positive and significant market betas in all portfolios (Panels E-F) mostly at the 1% and 5% levels, with the magnitude of the beta coefficients indicating that all portfolios had very low systematic risk. Furthermore, for the equal weighted portfolio, the HML factor was positive and significant at the 5% level, which indicates that all of India's equal weighted portfolios returns were sensitive to value stocks (high B/M ratios). Lastly, in both equal weighted portfolios for R&D growth and unexpected R&D, within the Carhart model, the momentum factors were positive 0.7037 (value weighted) and 0.6882 (equal weighted) and significant at the 10% level which suggests that stocks in this portfolio that performed well in the previous period are likely to continue to perform well in the following period. However, the result for India should be interpreted with caution because of the limited period of analysis due to the late enforcement of IFRS adoption as discussed in section 3.3.

The results for Chinese firms, shown in Panels G-H, are similar to those for India. Market betas were positive, but less than one, and significant, which suggests that Chinese firms engaged in R&D are defensive firms. All other risk factors were insignificant except for the momentum factor in the equal weighted portfolio under the Carhart four factor model for R&D growth. The momentum factor was negative (-0.4166) and significant at the 10% level with a p-value of 0.0702, which similar to the South African portfolio, indicated that stocks in these portfolios that performed poorly in the previous period will continue to do so in the next period, relative to stock portfolios who had outperformed in the prior period.

In all but one portfolio (Panels I-J) South African firms displayed market betas less than one which suggests that these portfolios are defensive. For the R&D growth portfolios in South Africa there was only one other significant risk factor bar the market betas. In the equal weighted portfolio within the Carhart four factor model the HML factor was positive (0.8873) and significant at the 1% level. This suggests that the portfolio was more sensitive to value stocks (high B/M ratios). For the unexpected R&D increase portfolios in South Africa, the value and equal weighted portfolios in the Carhart four factor model displayed negative (-0.1555 and -0.6879, respectively) and significant momentum factors. Therefore, it can be concluded that these portfolios comprise loser stocks.

The individual regressions for Brazil, Russia, China and South Africa had R-squared and adjusted R-squared values which were close to, but never exceeded 60%, much the same as the

BRICS nations regressed together as shown in Table 6. Overall this suggests that all portfolios in both models need additional factors to explain more of monthly returns in BRICS nations.

Overall, the study found that for the nations regressed on their own with both the Fama and French three factor model and Carhart four factor model, Brazilian and Russian firms with positive R&D growth or those with an unexpected increase in R&D do not earn abnormal returns in the long run as the alpha estimates were insignificant. In contrast, for the majority of models for both R&D growth and unexpected R&D increases, Chinese firms do earn abnormal returns in the long run mostly at the 10% level of significance with the magnitudes of the alphas ranging from 0.86% - 1.25%. These findings offer a considerable annual return range of 10.32%-15% for China.

India was the only other country where positive and significant alphas were found. For R&D growth, the equal weighted portfolio in the Fama and French three factor model had a positive alpha (1.26%) which was significant at the 10% level with a p-value of 0.0612. When considering unexpected R&D increases, the equal weighted portfolio in the Fama and French three factor model was also positive (1.17%) and significant at the 10% level with a p-value equal to 0.0729. As mentioned previously, the result for India should be interpreted with caution because of the limited period of analysis due to the mandating of IFRS adoption.

In contrast to all other BRICS countries, the study found that in all but one of the models for South Africa, for both R&D growth and unexpected R&D increases, negative and significant alpha terms, with alphas ranging from -0.79% to -1.03%. Therefore it can be concluded that these firms earn negative abnormal returns in the long run.

4.6 Analysis of the results

4.6.1 Analysis of the main sample results

As outlined previously, two contending theoretical arguments have been proposed for the positive relationship between R&D expenditure and subsequent market performance. This relationship could be attributed to market compensation for risk arising from R&D investments, or to market mispricing (Anagnostopoulou, 2008). In context of the EMH theory, if BRICS markets were efficient then the stock prices would have incorporated the income statement R&D expenditure into the stock price immediately and investors would not earn abnormal returns over the long-term. As firms grow it is likely that they would spend more on R&D and

investors would probably anticipate this (Eberhart, Maxwell & Siddique, 2004), therefore in terms of the R&D growth samples analysed within the study, the market can be expected to be efficient, where prices fully reflect the increase in R&D and no abnormal returns could be earned. On the other hand, there is less likelihood that the EMH holds when analysing the unexpected R&D increases, since they are “unexpected” and investors could either overreact which would lead to negative abnormal returns or under-react which would lead to positive abnormal returns.

Within the main sample, a positive and significant alpha in the value weighted portfolio based on the Fama and French three factor model for R&D growth (Table 6 Panel A) was found which contends with the argument of Eberhart, Maxwell and Siddique (2004), that the market anticipates firms to increase their R&D as they grow. Furthermore, the value weighted portfolio also within the Fama and French three factor model, but for the unexpected R&D increase (Table 6 Panel A) displayed a positive and significant alpha which is consistent with the argument that investors do not anticipate these unexpected increases in R&D. Therefore the null hypothesis can be rejected at the 10% level for both portfolios and it can be concluded that these portfolios do exhibit positive long-term abnormal returns.

The presence of such abnormal returns means that investors do not respond immediately to the good news about R&D and hence earn long-term abnormal returns, which attests to investor underreaction, that is the tendency for investors to underreact to new information (Malkiel, 2003) i.e. the R&D expenditures. The underreaction can be attributed to two things, namely, limited investor attention and the difficulty of processing information that is less tangible and more ambiguous. Therefore the stock prices did not fully and immediately impound the relevant public information about both the total and unexpected R&D changes as exhibited in studies conducted in more developed markets such as the U.S, U.K. and Europe (Eberhart, Maxwell & Siddique, 2004; Ali, Ciftci & Cready, 2012; Songur & Heavilin, 2017). However, not all of the findings showed positive abnormal long-term returns and thus there is some ambiguity as to whether the null hypothesis can be rejected.

The other perspective, however, is that that the positive relationship may in fact be due to an insufficient measure of risk (Chambers, Jennings & Thompson, 2002; Al-Horani, Pope and Stark, 2003) as opposed to irrational investor behaviour. That is, CAPM beta does not capture the risk associated with firms who have high R&D expenditures. The problem is it cannot be

ascertained as to whether the abnormal returns are due to irrational behaviour or an insufficient measure of risk because of the joint hypothesis problem i.e. when tests are performed, it is necessary to assume EMH and CAPM hold and so if the null hypothesis is rejected and it is concluded that there are abnormal returns it could be due to the failure of the EMH to describe the behaviour of investors (i.e. they are not rational) and/or the CAPM is a poor model. However, to avoid this problem, two more comprehensive asset pricing models were used to test the relationship rather than relying on the CAPM.

As documented in the main sample of the study (Table 6), the HML and momentum factors were never significant while the market beta and SMB factors were always significant, therefore it is possible that the abnormal returns may be due to the use of an inappropriate asset pricing model – especially since half of the risk factors are insignificant within the main sample. However, as discussed in Section 3.5, using a more comprehensive asset pricing model, such as the Fama and French three factor models, means that the chances of falsely rejecting the null hypothesis due to an inappropriate asset pricing model are reduced.

What is of particular importance with regards to the findings of the main sample is that both significant alphas appeared within the value weighted portfolios, however when the portfolios were equal weighted there were no significant alphas for either R&D growth or an unexpected increase in R&D expenditure. This finding may be attributable to the fact that Chinese firms make up 67% of the unexpected R&D increase sample and 61% of the expected R&D growth sample as displayed in Tables 1 and 2 and displayed positive and significant alphas in the majority of its own portfolios as demonstrated in Table 8, Panels G-H Therefore it can be said that when the portfolios of the main sample were equal weighted, this heightened the effect Chinese firms had on the sample. Furthermore, the South African portfolios which demonstrated negative abnormal returns in Table 8, would have had more of an effect on the main sample equal weighted portfolios and hence may have impacted in the result of the insignificant alphas for all equal weighted portfolios within the main BRICS sample of the study.

Moreover, since the positive relationship was found in the Fama and French model but disappeared in some of the Carhart models, it may suggest that the original finding is due to incorrect specification of the model.

Lastly, this study only focused on the expensed portion of R&D, which is the same accounting treatment as the U.S. under GAAP and the U.K. prior to 2005 (Tsoligkas & Tsalavoutas, 2011). Therefore, in theory since U.S. and U.K. (before 2005) firms only expense their R&D, the difference in findings in terms of the very limited evidence of positive abnormal returns in BRICS nations who apply IFRS, which also allows the capitalisation of R&D expenditure, compared to the U.S. and U.K. evidence of significant abnormal returns can be understood in that under IFRS, the amount of R&D expense on the income statement is likely to be lower relative to U.S. and U.K. companies.

4.6.2 Analysis of results the individual country results

Comparing the findings of the main sample of the study, to similar studies conducted on U.S. markets (Lev & Sougiannis, 1996; Eberhart, Maxwell & Siddique, 2004; Lev, Radhakrishnan & Ciftci, 2006) the findings were similar in that all studies found evidence of a positive relationship between the increase in R&D expenditure and subsequent abnormal returns. Thus, despite high levels of R&D in these countries, investors do not incorporate this information into prices immediately – possibly because they underact to new information and especially information related to R&D because it is unlikely to result in growth in revenues and returns to the company immediately. In this way the positive abnormal returns found in China and India are similar to the U.S.

In contrast, in Brazil and Russia, where insignificant alphas were observed, this could mean that investors respond to new R&D expenditure immediately or it could mean that investors do not assign any value to the information about R&D. A possible explanation for a lack of significance for R&D expenditure in some BRICS countries could be that they capitalise most of the expenditure, hence investors do not respond to the expenditure component of R&D. Furthermore, as evidenced in Tables 1 and 2, there are only a small number of Russian firms who undertook R&D. This is consistent with the evidence presented in Chapter 1 that much of the R&D is government-funded. In fact, in 2012 the Russian government agencies funded and undertook approximately 75% of total R&D expenditure (Jaax, 2017) and in 2020 this was still the case (Schiermeier, 2020). Similarly, multinational corporations (MNCs), rather than domestic firms, account for a large portion of total R&D in the private sector in Brazil (Reynolds, Schneider & Zylberberg, 2019), which may account for the insignificant alpha values as many of these MNCs are not listed on the Ibovespa Brasil Sao Paulo stock exchange.

Comparing the results to other studies conducted in BRICS nations, the finding that Indian firms earn abnormal returns in the long run differs slightly with the findings of Naik, Narayanan and Padhi (2012) who found an inverted U-shaped relationship between R&D intensity and firm value from their sample of 326 BSE-listed manufacturing firms between 2001 and 2010. However, this study did not allow for the possibility of an inverse relationship, which could explain the difference in the findings for Indian firms presented in Table 8 (Panels E-F). Another plausible explanation for the finding is that the two samples do differ from one another, this study's sample for the BSE represented all 20 major industries (except financial services) of the Indian economy, whereas Naik, Narayanan and Padhi (2012) focused only on listed manufacturing firms. Similar to Naik, Narayanan and Padhi (2012), Kim (2018) found that R&D investments have an inverted U-shaped relationship with firm value in China. The finding of a positive alpha is consistent with some of Kim's (2018) findings but whether returns differ depending on the level of R&D investment was not examined in this study.

The findings that South African firms did not earn abnormal returns in any of the models (Table 8. Panels I-J) but in fact earn negative abnormal returns may attest to the phenomenon of investor overreaction, that is investors initially overreact and then there is a subsequent correction. Overreaction can be defined as "overestimation of the precision of one's information" (Kukacka and Barunik, 2013: 5923). Therefore, it can be said that investors initially overreacted to both the increases in R&D and unexpected R&D increases for South African firms, by overstating the benefits to which R&D expenditure would give to these firms which would have initially increased the stock prices subsequent to a correction.

These findings differ significantly from Bhana (2001; 2013) and Ramaboa and Chen (2016). A possible explanation may lie in the fact that this study focused on the portion of R&D expenditure which appeared on the income statement as opposed to R&D announcements and R&D capitalisation which appears on the balance sheet, respectively. The fact that Bhana (2001) found R&D announcing firms experienced abnormal returns may attest to investor overreaction to the announcement. Furthermore, positive initial announcement returns does not seem to last given the findings related to long-term returns obtained in this study. Ramaboa and Chen (2016) focused on the capitalised portion of R&D which lacks standardisation and therefore can result in earnings inconsistencies.

The findings may also differ to Ramamboa and Chen (2016) since they acknowledged that most South African firms still expense R&D due to the difficulties in assessing R&D capitalised portions, however the study assumed all South African firms to have the same accounting treatment of R&D and focused on the capitalised portion. Therefore, it can be said that there is less “information” in the capitalised portion and more in the “expense” portion and therefore the latter should provide more information, which in the case of this study resulted in initial investor overreaction and subsequent correction.

A further possible explanation for significant alphas in the main sample of the study is that China and India (who represent over 90% of the sample when equal weighted), arguably some of the more developed nations within BRICS, rank 14th and 46th on the Global Innovation Index respectively (Dutta, Lanvin & Sacha Wunsch-Vincent, 2020: 32) and are not far off the U.S. who ranks 3rd in the index. Furthermore, China and India have R&D percentages of GDP equal 2.24% and 0.65% respectively, relative to the U.S. 3.067%. China alone has a greater R&D expenditure percentage of GDP relative to the U.K. which also may explain why the findings of the BRICS sample is similar to that of studies done in the U.K. (Toivanen, Stoneman & Bosworth, 2002; Al-Horani, Pope & Stark, 2003).

4.7 Summary

This chapter represented the results from the regression analysis of both the Fama and French three factor model and Carhart four factor model. The results revealed that only in the Fama and French three factor model value weighted portfolios for both R&D increases and unexpected R&D expenditure increases did these portfolios display positive and significant alphas. Therefore, it was concluded that only these portfolios within the main sample displayed positive long-term abnormal returns which attested to investor underreaction. Furthermore, the individual country results revealed that Brazil and Russia had no abnormal returns, China and India displayed positive abnormal returns while South Africa in fact displayed negative long-term abnormal returns which attested to investor over-reaction.

5. Conclusion

The research objectives of the study were to determine the effect on the long-term share price performance of firms in the BRICS countries of total and unexpected R&D expenditure increases. This relationship has been extensively studied in developed markets such as the U.S. and U.K. while there is a dearth of research conducted in developing markets. The research focused on the R&D expense portion found on a company's income statement as opposed to the capitalised portion found on the balance sheet. Moreover, the main aim was to determine if R&D expenditures result in abnormal returns across the BRICS nations and, as such, access whether a similar mispricing, which had been demonstrated in the U.S. and U.K. markets exists.

It is valuable to examine the issue within BRICS nations since R&D incubates and facilitates innovative solutions and advancements, where the majority of economists agree that innovation plays a crucial part in creating and navigating economic growth and competitiveness (Moncada-Paternò-Castello et al., 2010). Moreover, innovation is especially important for emerging countries due to the prevalent and persistent wide disparity in the social and living standards measures in the respective nations (Blanco, Delgado & Presno, 2020).

The results revealed that only under the Fama and French three factor model, with value weighted portfolios for both R&D growth and unexpected R&D expenditure increases did these portfolios display positive and significant alphas. Therefore, it was concluded that only these portfolios within the main sample displayed positive long-term abnormal returns which attested to investor underreaction as displayed in U.S. and U.K. markets. However, in the two cases where alpha was significant under the Fama and French three factor model but not the Carhart four factor model. This may suggest that the abnormal returns earned under the Fama and French model are actually attributable to momentum in stock returns i.e. that the stocks that have performed well (poorly) in the past continue to perform well (poorly) rather than the abnormal return being attributable to the firm's unexpected R&D expenditure or R&D growth.

The results and subsequent findings thus suggest that due to moderate investor consideration and the complexities of analysing the accounting treatment of R&D under IFRS, stock prices do not instantly and/or fully reflect the related public information of expected and unexpected R&D expenditure increases within the BRICS nations.

The implications of the findings present an opportunity for market participants to earn abnormal returns by investing in BRICS companies who increase their R&D regularly or those who have unexpected increases in R&D. Furthermore, the results can be useful to financial statement users and firm managers to understand the impact of the chosen accounting treatment of R&D under IFRS. The results may be used for manager motivation to begin or continue to spend on R&D for their firms and may further result in increased shareholder value.

The study encountered a number of issues and has made the following recommendations for further research on such issues.

Firstly, when collecting data from Bloomberg, R&D expenditure was not reported for all firms. This has implications for the portfolio formations, the portfolios were formed by calculating the R&D/Assets ratio and computing R&D growth, however some ratios and R&D growth figures were not able to be computed due to missing reported figures of firms. Therefore, it can be said that some stocks were either not included in portfolios at all or only partially included due to the data unavailability on Bloomberg.

In the analysis the Russian firms displayed no significant alphas mainly due to the fact that the Russian government undertakes majority of R&D expenditure within the country. Further studies could focus solely on such government entities as opposed to listed firms on the MOEX and assess whether the relationship would change. The same applies to Brazilian firms where most of their R&D is undertaken by MNCs.

Although the study followed the methodology of Eberhart, Maxwell and Siddique (2004) in computing simple returns, the author does acknowledge that the computation of returns using compounding is more common and could be a limitation and room for further analyses. This paper did not focus on operating profits after the R&D increase as per Eberhart, Maxwell and Siddique (2004), which further research in BRICS nations could focus on. Moreover, the study exclusively focused on using the same methodology as Eberhart, Maxwell and Siddique (2004), further research could utilise an alternative methodology such as those followed in other seminal literature (Nguyen, Nivoix & Noma, 2010; Duqi, Mirti & Torluccio, 2011; Ramaboa & Chen, 2016)

The HML and momentum factors were largely insignificant, therefore it stands to reason that other factors which could further explain the monthly returns of the BRICS portfolios should

be added to the model. For example, the Fama and French five factor model could be utilised. Moreover, factors such as the size of financial markets, data availability problems, ownership structures and law systems which have impacted market valuations in relation to R&D expenditures have been documented in several European nations (Hall & Oriani, 2006; Duqi, Mirti & Torluccio, 2011; Duqi & Torluccio, 2013) and could be used in extended models when analysing BRICS nations.

Further research on the paper topic could be performed again using a similar methodology in about 5-10 years in order for all BRICS nations to have used the IFRS accounting treatment for a longer period due to the short time period examined for India. Moreover, the sample could extend to more emerging markets.

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7. Appendices

Table A1: BRICS 2007 Descriptive Stats

Statistic	Mean	Standard deviation
Total assets (\$MM)	75047.0450	559050.9659
Market capitalisation (\$MM)	58176.9368	276324.4696
Unexpected R&D increases: R&D/assets	1.6398%	15.2106%
Average monthly return Value weighted	3.5532%	17.2263%
Equal weighted	0.8881%	7.6633%
R&D Growth: Dollar increase in R&D	60.0167	673.9190
Average monthly return Value weighted	0.0361	0.1725
Equal weighted	0.9956%	8.1530%

Table A2: Individual BRICS nations descriptive statistics

Country: Brazil		
Statistic	Mean	Standard deviation
Total assets (\$MM)	84745.1907	178966.9714
Market capitalisation (\$MM)	39163.4438	73907.6627
Unexpected R&D increases: R&D/assets	0.3111%	0.4233%
Average monthly return Value weighted	0.4962%	6.0466%
Equal weighted	0.3072%	9.4143%
R&D Growth: R&D Growth	3.0052	165.8242
Average monthly return Value weighted	0.3101%	5.7952%
Equal weighted	0.1180%	9.7436%

Country: Russia		
Statistic	Mean	Standard deviation
Total assets (\$MM)	1233194.3708	4191483.8900
Market capitalisation (\$MM)	374088.9793	1045074.9966
Unexpected R&D increases: R&D/assets	0.0472	0.1069
Average monthly return Value weighted	0.6562%	8.5336%
Equal weighted	1.3177%	8.3388%
R&D Growth: R&D Growth	212.0303	2296.4050
Average monthly return Value weighted	0.6552%	6.0848%
Equal weighted	0.7700%	9.4009%
Country: India		
Statistic	Mean	Standard deviation
Total assets (\$MM)	227851.0962	745623.8598
Market capitalisation (\$MM)	226578.8951	670970.8826
Unexpected R&D increases: R&D/assets	0.0552	0.4628
Average monthly return Value weighted	0.4144%	3.3100%
Equal weighted	1.6696%	7.6696%
R&D Growth: R&D Growth	56.5341	1827.5843
Average monthly return Value weighted	0.6911%	4.2025%
Equal weighted	1.7149%	7.7077%

Country: China		
Statistic	Mean	Standard deviation
Total assets (\$MM)	40015.7669	134156.5858
Market capitalisation (\$MM)	29995.86698	104694.0208
Unexpected R&D increases: R&D/assets	0.0156	0.0226
Average monthly return Value weighted	0.9359%	4.9353%
Equal weighted	0.9524%	8.0414%
R&D Growth: R&D Growth	64.3403	390.7731
Average monthly return Value weighted	0.9558%	4.6166%
Equal weighted	1.0984%	8.5869%
Country: South Africa		
Statistic	Mean	Standard deviation
Total assets (\$MM)	30497.15921	61171.85352
Market capitalisation (\$MM)	116936.7467	349649.1431
Unexpected R&D increases: R&D/assets	0.002499748	0.013340363
Average monthly return Value weighted	-0.1576%	2.4010%
Equal weighted	-0.1751%	6.6361%
R&D Growth: R&D Growth	0.4641	20.5760
Average monthly return Value weighted	-0.2559%	3.6791%
Equal weighted	-0.4825%	7.0249%