

**Negative investment returns in a developing market context**

**by**

**Pravin Semnarayan**

**Student number: 04271815**

**Submitted in fulfilment of the requirements for the**

**degree of Doctor of Philosophy**

**at the Gordon Institute of Business Science,**

**University of Pretoria**

**30 January 2020**

**Supervisor: Professor Michael Ward**

**Co-supervisor: Mr Chris Muller**

## Abstract

The traditional asset-pricing models dominating extant literature have produced many empirical failures. These models are based on market-side variables, without incorporating the firm side. This research extends the nascent investment-based asset-pricing theory (IBAPT), which relates share return directly to firm characteristics and explains why share returns are lower for firms with a higher rate of investment. IBAPT was conceptualized using United States-developed data and there is debate about the significance of this phenomenon under developing market conditions. Undertaking such analysis in developing market contexts has been rendered problematic by the lack of adequate data and the high costs of assembling an analysis system to model the data. The researcher resolved these problems.

This study builds on the IBAPT by drawing evidence from the high-risk, high-volatility and low-turnover South African developing market context, distinctly different from the US. It further extends the concept of firm investment in the IBAPT by examining the impact of previously un-studied investment variables.

It found the relationship between firm investment ('I') and subsequent share return ('R') was related to investment and lag periods, uncovering a significant negative I–R relationship with optimised investment and lag periods in this context. The return premium associated with firm investment style was significantly higher than 100 random investment styles tested on the Johannesburg Stock Exchange. It found that the I–R relationship can be associated with abnormal effects in the market (value-versus-growth, size, equity issuance, debt-to-equity and profitability), also dependent on investment and lag periods.

This work thus contributes to the development of IBAPT scholarship, and suggests that future studies should attend carefully to investment and lag period variables. At the practitioner level, the work enhances the utility of IBAPT in determining pricing and investment decisions for listed as well as private firms, since the valuation method does not require factors aggregated from the market.

**Keywords:** investment-based asset-pricing theory, investment CAPM, q-factor, firm investment, shareholder return, asset growth

## **Declaration**

I, Pravin Semnarayan, declare that this thesis, which I hereby submit for the degree of Doctor of Philosophy, at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

Pravin Semnarayan

## **Acknowledgements**

I wish to acknowledge my supervisors Michael Ward and Chris Muller, the GIBS research support team, Gwen Ansell for assisting with language editing, and Francois Steffens for assisting with statistics.

## Table of contents

<b>Abstract .....</b>	<b>i</b>
<b>Declaration .....</b>	<b>ii</b>
<b>Acknowledgements .....</b>	<b>iii</b>
<b>Table of contents .....</b>	<b>iv</b>
<b>List of figures .....</b>	<b>viii</b>
<b>List of tables.....</b>	<b>x</b>
<b>List of equations .....</b>	<b>xi</b>
<b>List of abbreviations and acronyms .....</b>	<b>xii</b>
<b>Chapter 1: Introduction .....</b>	<b>1</b>
1.1    Background .....	1
1.2    Problem statement .....	2
1.3    Purpose statement .....	3
1.4    Research questions .....	4
1.5    Scope .....	4
1.6    Delimitations of the study.....	5
1.7    Definitions of key terms .....	5
1.8    Organisation of the thesis .....	9
<b>Chapter 2: Context.....</b>	<b>10</b>
2.1    The South African developing market context.....	10
2.2    Difference between the South African and United States markets .....	13
<b>Chapter 3: Literature review.....</b>	<b>16</b>
3.1    Investment-based asset-pricing theory (IBAPT).....	18
3.2    Risk-based models .....	26

3.2.1	Consumption-based asset-pricing.....	26
3.2.2	Real options model .....	28
3.2.3	Macroeconomic risk model .....	31
3.2.4	Empirical asset-pricing models .....	32
3.3	Contrasting behavioural theories .....	36
3.3.1	Limits to arbitrage .....	36
3.3.2	Overinvestment.....	37
3.3.3	Mispricing .....	38
3.4	Summary of the literature .....	41
3.5	Conceptual model and hypotheses.....	43
3.5.1	I–R relationship, investment and lag periods.....	43
3.5.2	Significant negative I–R relationship .....	44
3.5.3	I–R association with abnormal effects.....	45
<b>Chapter 4: Research design and methodology .....</b>		<b>49</b>
4.1	Research process.....	49
4.2	Research philosophy and approach.....	50
4.3	Buy-and-hold portfolio research strategy .....	51
4.4	Time horizon.....	52
4.5	Unit of analysis, population and sample.....	52
4.6	Data.....	54
4.7	Firm investment process.....	54
4.8	Operationalisation of variables.....	56
4.9	Research procedures .....	57
4.9.1	I–R relationship, investment and lag periods.....	57

4.9.2	Significant negative I–R relationship .....	59
4.9.3	I–R association with abnormal effects .....	61
4.10	Quality assurance .....	64
4.11	Reliability and validity .....	66
4.12	Limitations of the study .....	66
4.13	Ethical considerations .....	66
<b>Chapter 5: Results</b> .....		<b>67</b>
5.1	I–R relationship, investment and lag periods .....	67
5.2	Significant negative I–R relationship .....	73
5.3	I–R association with abnormal effects .....	75
5.4	Summary of key results .....	93
<b>Chapter 6: Discussion</b> .....		<b>94</b>
6.1	Methodological differences .....	94
6.2	Contextual differences .....	95
6.3	Further enhancements to investment-based asset-pricing theory .....	95
6.3.1	I–R relationship, investment and lag periods .....	96
6.3.2	Significant negative I–R relationship .....	96
6.3.3	I–R association with abnormal effects .....	97
6.4	Summary of key insights .....	100
<b>Chapter 7: Conclusion and recommendations</b> .....		<b>101</b>
7.1	Research problem .....	101
7.2	Methodology .....	103
7.3	Results .....	104
7.4	Discussion .....	105
7.5	Importance and contribution of the study .....	107

7.5.1	The theoretical contribution.....	108
7.5.2	The methodological contribution .....	109
7.5.3	The practical contribution .....	110
7.5.4	The policy contribution .....	110
7.6	Recommendations for future research.....	111
<b>List of references .....</b>		<b>112</b>
<b>Appendices .....</b>		<b>120</b>
Appendix A: Results modelled on linear measure of firm investment.....		120
A.1.	I–R relationship, investment and lag periods.....	120
A.2.	Significant negative I–R relationship .....	123
Appendix B: Visual representations of I–R association with abnormal effects .....		126



## List of figures

Figure 2.1: South African GDP annual growth rate (quarter on quarter annualised) .....	12
Figure 2.2: South African interest rate and inflation trend.....	12
Figure 2.3: Volatility and price trend of the J203 (All Share Index) .....	13
Figure 3.1: Conceptual model .....	43
Figure 4.1: Investment process variables and illustration of 'look-back' parameters ( $[-4,-2]$ example) .....	55
Figure 4.2: Illustration of cases .....	63
Figure 5.1: Quintiles ranked on firm investment (with look-back $[-4,-2]$ ) .....	68
Figure 5.2: Share returns for the highest firm investment quintile (LOGEST measure of firm investment) .....	70
Figure 5.3: Share returns for the lowest firm investment quintile (LOGEST measure of firm investment) .....	71
Figure 5.4: Difference of share returns between the lowest firm investment quintile and the highest firm investment quintile (LOGEST measure of firm investment) .....	72
Figure 5.5: High-investment Q1 $[-2,0]$ and low-investment Q5 $[-4,-2]$ portfolios with confidence limits (LOGEST measure of firm investment) .....	73
Figure A.1: Share returns for the highest firm investment quintile (linear measure of firm investment) .....	120
Figure A.2: Share returns for the lowest firm investment quintile (linear measure of firm investment) .....	121
Figure A.3: Difference of share returns between the lowest firm investment quintile and the highest firm investment quintile (linear measure of firm investment).....	122
Figure A.4: High-investment Q1 $[-2,0]$ and low-investment Q5 $[-4,0]$ portfolios with confidence limits (linear measure of firm investment).....	123

Figure A.5: Book-to-market ratio for Q1[-2,0] and Q5[-4,-2] (optimised case).....	126
Figure A.6: Book-to-market ratio for Q1[-2,0] and Q5[-2,0] (short horizon case).....	127
Figure A.7: Book-to-market ratio for Q1[-4,-2] and Q5[-4,-2] (medium horizon case).....	127
Figure A.8: Book-to-market ratio for Q1[-10,-3] and Q5[-10,-3] (long horizon case).....	128
Figure A.9: Market value for Q1[-2,0] and Q5[-4,-2] (optimised case).....	128
Figure A.10: Market value for Q1[-2,0] and Q5[-2,0] (short horizon case) .....	129
Figure A.11: Market value for Q1[-4,-2] and Q5[-4,-2] (medium horizon case) .....	129
Figure A.12: Market value for Q1[-10,-3] and Q5[-10,-3] (long horizon case) .....	130
Figure A.13: Equity issuance for Q1[-2,0] and Q5[-4,-2] (optimised case) .....	130
Figure A.14: Equity issuance for Q1[-2,0] and Q5[-2,0] (short horizon case) .....	131
Figure A.15: Equity issuance for Q1[-4,-2] and Q5[-4,-2] (medium horizon case) .....	131
Figure A.16: Equity issuance for Q1[-10,-3] and Q5[-10,-3] (long horizon case) .....	132
Figure A.17: Debt-to-market equity ratio for Q1[-2,0] and Q5[-4,-2] (optimised case) .....	132
Figure A.18: Debt-to-market equity for Q1[-2,0] and Q5[-2,0] (short horizon) .....	133
Figure A.19: Debt-to-market equity for Q1[-4,-2] and Q5[-4,-2] (medium horizon) .....	133
Figure A.20: Debt-to-market equity for Q1[-10,-3] and Q5[-10,-3] (long horizon) .....	134
Figure A.21: Profitability for Q1[-2,0] and Q5[-4,-2] (optimised case).....	134
Figure A.22: Profitability for Q1[-2,0] and Q5[-2,0] (short horizon case) .....	135
Figure A.23: Profitability for Q1[-4,-2] and Q5[-4,-2] (medium horizon case) .....	135
Figure A.24: Profitability for Q1[-10,-3] and Q5[-10,-3] (long horizon case) .....	136

## List of tables

Table 2.1: Indicators of market development and level of arbitrage (average over the period 1988 to 2017) .....	14
Table 4.1: All firms on the JSE at the end of 2017 (31 December 2017) .....	52
Table 4.2: Largest 160 firms on the JSE at the end of 2017 (excluding mining and financial services) (31 December 2017) .....	53
Table 4.3: Definition of operational variables.....	56
Table 5.1: Paired samples test difference between Q1[-2,0] and Q5[-4,-2] (31 December 1995 to 31 March 2019) .....	75
Table 5.2: Paired samples test difference of effects .....	76
Table 5.3: Results I–R association with abnormal effects.....	79
Table A.1: Paired samples test difference between Q1[-2,0] and Q5[-4,0] .....	125

## List of equations

Equation 3.1: The discounted cash flow (DCF) equation.....	16
Equation 3.2: Cochrane's (1991) investment return equation.....	19
Equation 3.3: The two-period investment CAPM equation .....	20
Equation 3.4: The q-factor asset-pricing model (or 'q-factor model' or 'HXZ model') .....	22
Equation 3.5: Berk et al.'s (1999) expected return equation.....	29
Equation 3.6: The basic CAPM equation.....	32
Equation 3.7: Fama and French (1992, 1993) three-factor equation .....	34
Equation 3.8: Fama and French (2015) five-factor equation.....	35

## List of abbreviations and acronyms

<b>ALSI</b>	All Share Index
<b>AMEX</b>	The American Stock Exchange
<b>ANC</b>	African National Congress
<b>APM</b>	arbitrage pricing model
<b>Capex</b>	capital expenditure
<b>CAPM</b>	capital asset-pricing model
<b>CMA</b>	conservative minus aggressive investment factor
<b>CPI</b>	consumer price index
<b>DCF</b>	discounted cash flow
<b>Df</b>	degrees of freedom
<b>EMH</b>	efficient market hypothesis
<b>FDI</b>	foreign direct investment
<b>GDP</b>	gross domestic product
<b>HML</b>	high minus low
<b>IBAPT</b>	investment-based asset-pricing theory
<b>IGR</b>	investment growth rate
<b>I–R</b>	firm investment–subsequent shareholder return
<b>IVOL</b>	idiosyncratic volatility
<b>JSE</b>	Johannesburg Stock Exchange
<b>NASDAQ</b>	National Association of Securities Dealers Automated Quotations
<b>NPV</b>	net present value
<b>NYSE</b>	New York Stock Exchange
<b>PhD</b>	Doctor of Philosophy
<b>PTH</b>	price-to-high
<b>QR</b>	Quarter

<b>R &amp; D</b>	research and development
<b>RMW</b>	robust minus weak profitability factor
<b>ROE</b>	return on equity
<b>SA</b>	South Africa
<b>SARB</b>	South African Reserve Bank
<b>SMB</b>	small minus big
<b>Stats SA</b>	Statistics South Africa
<b>US</b>	United States of America
<b>VBA</b>	Microsoft Visual Basic for Applications

## Chapter 1: Introduction

Previous literature lacked consensus as to the significance and importance of the relationship between firm investment and share return, with differing and contrasting explanations formulated on United States of America (US or United States) data (discussed in section 1.1). Traditional consumption-based asset-pricing models cannot explain this phenomenon (discussed in section 1.2). Investment-based asset-pricing theory (IBAPT) that relates investment by a firm ('firm investment', 'investment', or 'I') and subsequent shareholder return ('share return' or 'R') offers a new approach to asset-pricing that explains this relationship and also explains other abnormal effects observed in the market (discussed in section 1.2). The researcher managed to obtain data and software to test this theory and develop it further (discussed in section 1.3) in the South African context, which is distinct and different from that of the United States (discussed in sections 1.1 and 1.3).

The current research was designed to answer whether the firm investment–subsequent share return relationship (I–R) is significant and negative under high-volatility and low-turnover conditions, what the impact of investment process variables is, and whether IBAPT is associated with abnormal effects in this market (discussed in section 1.4). The scope of the study is discussed in section 1.5 and key terms used in the study are defined in this chapter (section 1.6).

Part of this Doctor of Philosophy (PhD) study process was the article (Semnarayan, Ward, & Muller, 2018) that was published, with my supervisors as co-authors, which helped refine this thesis. Definitions and some aspects of this study are also presented in Semnarayan et al. (2018).

### 1.1 Background

It was widely assumed that there should be a positive association between firm investment and subsequent shareholder return. Instead, multiple previous studies on US data have found that there is a negative relationship, with multiple explanations and contrasting views for this negative relationship between firm investment and subsequent shareholder return (e.g. Alti & Tetlock, 2014; Anderson & Garcia-Feijóo, 2006; Berk, Green, & Naik, 1999; Cooper, Gulen, & Schill, 2008; Cooper & Priestley, 2011; Cordis & Kirby, 2017; George, Hwang, & Li, 2018; Hou, Xue, & Zhang, 2015; Lam & Wei, 2011; Li & Zhang, 2010; Lin, Li & Yuan, 2018; Lipson, Mortal, & Schill, 2011; Mortal & Schill, 2015; Peters & Taylor, 2017; Song, 2016; Stambaugh & Yuan, 2017; Titman, Wei, & Xie, 2004; Titman, Wei, & Xie, 2013; Xing, 2008; Zhang, 2017). Traditional consumption-based asset-pricing models (see section 3.2.1) fail to explain why share returns are lower for firms with a higher rate of

investment as compared to firms with a lower rate of investment. Academics and practitioners have therefore turned to a behavioural-based explanation (see section 3.3), attributing the negative I–R relationship to overinvestment by firms and mispricing behaviours by investors. The IBAPT (see section 3.1) offers a new perspective, based on economic and finance fundamentals, incorporating the perspective of the firm and the market in asset-pricing.

This area of research – understanding the relationship between investment and share return – remains underdeveloped. Additionally, the effects of time, type of investment and financing structures on the relationship between firm investment and share return remain debated. These and what they mean for this research are detailed in Chapter 3 below.

No analysis of this kind has been conducted previously in a developing market such as South Africa, because of the costs of and limitations on obtaining suitable data. However, this researcher was able to access a comprehensive database of company financial statements and JSE (Johannesburg Stock Exchange) share prices over a significantly long period, and buy-and-hold portfolio research software. This made the present study possible, and permitted an enquiry to determine the existence of, and study, the negative I–R relationship in a developing economy context (such as South Africa) that is distinct from and different to the United States.

## **1.2 Problem statement**

Asset-pricing is unfortunately dominated by consumption-based asset-pricing studies, which relate expected share return to demand or market variables, ignoring the firm or supply side (Zhang, 2017). Zhang (2017) argues that this consumption paradigm is conceptually incomplete and has therefore failed empirically (see section 3.2).

This comment implies that practitioners (firms and shareholders) faced with investment decisions would gain considerable utility from a rational model that understands share return from the perspective of the firm, and which is based on firm characteristics. This study therefore investigated whether the IBAPT can explain the I–R ‘anomaly’, which is unexplained by consumption-based asset-pricing models.

However, understanding the relationship between firm investment and shareholder returns by employing the IBAPT to relate firm variables to market variables is a relatively new and undeveloped approach (Zhang, 2017). IBAPT is causal based on fundamental firm variables that relates the activities of a firm directly to its value and returns on the market. IBAPT is new for both academics and practitioners, and its reliability as a theory remains to be tested, preferably using data derived from outside the United States (Zhang, 2017). Zhang (2017) consequently challenges researchers to test and develop the theory outside the United States.



Most research to date was based on the exhaustive mining of US data (Zhang, 2017). By contrast, the current research used extensive South African firm and market data derived from a context (the JSE) where arbitrage costs and risks are high (see Chapter 2). It was not previously clear whether a rational explanation for the relationship between firm investment and share return in this context exists (Titman et al., 2013). The current study tried to sustain the use of rational economics in explaining the negative I–R phenomenon in a context with high arbitrage costs and high-risk. Zhang (2017) argues that theorists resort to market inefficiency explanations for anomalies that actually stem from the design flaws of consumption-based asset-pricing models. It is for this reason that the current study employed the IBAPT, which takes into account the firm perspective and provides a rational explanation for the negative I–R relationship.

### **1.3 Purpose statement**

Asset-pricing is central to finance (Zhang, 2017). The purpose of the current research was to examine the relationship between firm investment and shareholder return in a developing market context, and further develop the IBAPT that explains this relationship. The current research is built on the rational IBAPT (explained in section 3.1), under high-risk and high-arbitrage cost conditions. The IBAPT was initially conceptualised by Cochrane (1991), leveraging the analogous traditional consumption-based q-theory of investment. The IBAPT is core to a rational explanation for the negative I–R relationship, and the anchor of this thesis. Consumption-based asset-pricing studies and behaviour-based studies have dominated the literature. IBAPT is nascent to asset-pricing and explains the negative I–R relationship, by suggesting that firms optimise investment levels to maximise their market equity value, and invest such that their cost to capital equals market returns. This means that firms make higher investments on low cost of capital projects, which relates to lower share returns on the market. Risk-based theory and models (see section 3.2) have ignored the perspective of the firm in relating share return on the market, and for this reason these models have exhibited empirical failure.

Previous studies have employed cross-sectional analysis (Cochrane, 1991; Hou et al., 2015; Liu, Whited, & Zhang, 2009); whereas the current study was based on a time-series methodology. This study further considered the impact of timing, in terms of investment period (or capital expenditure period) and lag period, on the I–R relationship. Previous studies (Cochrane, 1991; Hou et al., 2015; Liu et al., 2009) have employed a linear measure, whereas the current study used the traditional linear measure as well as the Excel LOGEST function to determine firm investment.

Additionally, the study examined whether the I–R relationship is associated with the value-versus-growth, size, equity issuance, debt-to-market equity, and profitability abnormal effects observed in the market, as well as the implications of investment and lag periods on these relationships.

## **1.4 Research questions**

Previous studies in the United States show a negative I–R relationship. The IBAPT explains this relationship and also suggests that abnormal value-versus-growth, size, equity issuance and profitability effects are related to this relationship between firm investment and subsequent share return. The q-factor model, developed on IBAPT, further mathematically accounts for these ‘anomalies’ in the market. In the South African context, it was not previously known whether investment is a significant predictor of share return, whether investment could explain abnormal effects, and whether the IBAPT holds in a context of high-volatility, low-turnover and high-risk. Nor had the impact of timing, length of investment period and lag period been studied before. The current research further extended the IBAPT, using different measures of firm investment, incorporating the dimensions of investment period and lag period, and using time-series methodology.

The research questions were:

- Can firm investment, measured at firm level, be directly related to subsequent share return, measured at market level, in a developing market context of high-risk conditions, and high limits to arbitrage?
- Is the I–R relationship negative and significant, as conceptualised by IBAPT, in this market?
- What is the impact of the investment process (investment and lag periods), on the IBAPT, in terms of the I–R relationship?
- Does the I–R relationship account for abnormal effects observed in the market, which previously had been unexplained by traditional asset-pricing models?
- What is the impact of the investment process (investment and lag periods) on the IBAPT, in terms of the association between I–R and abnormal effects observed in the market?
- What is the impact of using different measures of firm investment on the significance of the I–R relationship?
- What is the impact of time-series, instead of cross-sectional analysis, on the IBAPT?

## **1.5 Scope**

From the perspective of IBAPT, this study sought to examine the relationship between firm investment and subsequent share returns. It did not test the perspectives of the alternate behavioural finance or consumption-based asset-pricing models. The scope of the study was limited to firms

listed on the main board of the JSE during the study period. The data was modelled from 30 September 1987 to 31 March 2019, but due to start-up issues in the data, data from later years was used in some of the analysis. Financial services and mining firms were excluded from the sample.

## 1.6 Delimitations of the study

The delimitations of the study are –

- The study did not probe the influence of behavioural factors.
- The current research employed data from the JSE: a relatively small exchange.
- The current research did not test data from other exchanges.
- The study excluded mining and financial services firms.
- The effect of intangibles was not specifically studied.
- The study was limited to listed firms.
- Real options theory was not studied.
- The study contributes to but does not propose a fully developed asset-pricing model.

## 1.7 Definitions of key terms

<b>Anomaly:</b>	An observation that is different from what is generally expected and (in this context) is explained by traditional asset-pricing models such as the capital asset-pricing model (CAPM) (Fama & French, 2012a).
<b>Asset:</b>	The tangible and intangible resources of the firm that are used to create products, resulting in value for the firm, equivalent to the equity value of the firm listed on the stock exchange (Cochrane, 1991, 1996).
<b>Arbitrage:</b>	The simultaneous purchase and sale of similar assets for advantageously different prices (Shleifer & Vishny, 1997).
<b>Arbitrageur:</b>	An investor who engages in arbitrage (Shleifer & Vishny, 1997).
<b>Assets-in-place:</b>	The discounted projected cash flows from existing assets of the firm (Cao, Simin, & Zhao, 2008).
<b>Behaviour:</b>	The actions of managers of the firm with respect to investment policies and decisions, and of investors with respect to pricing of assets (Alti & Tetlock, 2014).

<b>Bootstrap:</b>	A statistical technique to determine properties of a population by drawing samples repeatedly and randomly from the original sample (Jeong & Chung, 2001).
<b>Capital adjustment costs:</b>	The loss or adjustment required to reach high production levels during periods of high firm investment (Cochrane, 1996).
<b>Cost of capital:</b>	The opportunity cost of the investment, equivalent to the required rate of return of an asset of equal risk as the investment (Cochrane, 1991, 1996; Fama & French, 1992, 1993; Lintner, 1965; Mossin, 1966; Sharpe, 1964; Treynor, 1962). This is the hurdle rate to be exceeded for the investment to be viable.
<b>Firm investment:</b>	The growth in net assets of the firm, which reflects activities such as capital investment and acquisitions (Cooper et al., 2008).
<b>Frictionless markets:</b>	A theoretically complete market where there are no costs or risks when making a transaction (Alti & Tetlock, 2014; Lam & Wei, 2011; Li & Zhang, 2010).
<b>Future cash flows:</b>	The net incremental real cash flows realised from investing in the asset (Cochrane, 1991, 1996; Fama & French, 1992, 1993; Lintner, 1965; Mossin, 1966; Sharpe, 1964; Treynor, 1962).
<b>Glamour stocks (or shares):</b>	Stocks (or shares) that have done well recently and which are favoured by investors, with higher market value relative to earnings or book value of assets (Lakonishok, Shleifer & Vishny, 1994; Shleifer & Vishny, 1997).
<b>Growth firms:</b>	Firms with low book-to-market ratio (Anderson & Garcia-Feijóo, 2006, p.172).
<b>Growth options:</b>	The potential future cash flow from future projects, related to the investment that is made today (Berk et al., 1999). The present value of growth options can be estimated as the difference between the market equity value and the value of assets-in-place divided by the market equity value (Cao et al., 2008).
<b>Hubris:</b>	Excessive confidence, pride, impulsiveness and a need for power on the part of the manager of a firm, often to the detriment of the firm and shareholders (Haynes, Hitt, & Campbell, 2015; Picone, Dagnino, & Minà, 2014).
<b>Idiosyncratic volatility (IVOL):</b>	The standard deviation between the share return and the market index return, specific to the share and which is unsystematic (Li & Zhang, 2010).
<b>Information asymmetry:</b>	The inequality of knowledge of the firm between managers and investors (Bessler, Drobetz, & Grüninger, 2011).

<b>Investment:</b>	The investment in assets for the firm that would require internal or external financing (Cochrane, 1991, 1996; Fama & French, 1992, 1993; Lintner, 1965; Mossin, 1966; Sharpe, 1964; Treynor, 1962).
<b>Investment factor:</b>	The low-investment portfolio return divided by the high-investment portfolio return (Anderson & Garcia-Feijóo, 2006; Cooper & Priestley, 2011; Xing, 2008).
<b>Firm investment–subsequent share return:</b>	The relationship between the firm investment and subsequent return to the shareholders of the firm.
<b>Investment frictions:</b>	The costs or risks of making a transaction (Alti & Tetlock, 2014; Lam & Wei, 2011; Li & Zhang, 2010).
<b>Long option:</b>	An option giving the investor the right to buy the share at a specified exercise price on or before the exercise date, hedging that the price of the share will rise (Merton, 1973).
<b>LOGEST:</b>	The Excel LOGEST function fits an exponential, best-fit, growth-rate curve to the share return ('y'), using the change in net assets ('x') for each interval within the measurement period, according to the equation $y = bm^x$ , where 'm' is a constant base, and b is a constant. All the points with the measurement period are used, in contrast to the linear measure that uses only the start and end points, and the points in between are ignored (Microsoft, 2019).
<b>Marginal-q:</b>	The net present value (NPV) of future cash flows generated from one additional unit of capital (Brainard & Tobin, 1968; Cochrane 1991, 1996; Tobin, 1969). NPV represents the net cash flow of the investment, discounted to the present value by the capital cost of the investment (McCallum, 1992) as per Equation 3.1 below.
<b>Market equity value:</b>	The closing share price multiplied by the number of shares of the firm.
<b>Mispricing:</b>	The market value of a firm divided by its true value, where a ratio above 1 implies that the price exceeds the true value and a ratio below 1 implies that the price is below the true value (Alti & Tetlock, 2014).
<b>Optimal investment:</b>	A situation in which the marginal cost of investment equals the marginal benefit of investment (Liu et al, 2009; Xing, 2008).

<b>Risk:</b>	Exposure to loss (Cochrane, 1991, 1996; Fama & French, 1992, 1993; Lintner, 1965; Mossin, 1966; Sharpe, 1964; Treynor, 1962). Systematic risk (beta) is generally calculated using linear regression (based on the linear CAPM model) over a chosen historical period, based on a chosen market benchmark and risk-free rate for the share, or calculated as the covariance between the share return and the market return divided by the market return volatility (variance) (Iress, 2018).
<b>Risk factors:</b>	The determinants of the return premium expected from the asset, based on the probability of losses from the asset (Cochrane, 1991, 1996; Fama & French, 1992, 1993; Lintner, 1965; Mossin, 1966; Sharpe, 1964; Treynor, 1962).
<b>Scrip dividend:</b>	An option whereby shareholders are able to choose to receive dividends in the form of shares instead of cash (Lasfer, 1997).
<b>Short option:</b>	An option that gives the investor the right to sell the share at a specified exercise price on or before the exercise date, hedging that the share price will fall (Merton, 1973).
<b>Style engine:</b>	The data collection and data analysis application, using a Microsoft Access database, Microsoft Excel spreadsheet application, and Microsoft Visual Basic for Applications (VBA) software programming language (Muller & Ward, 2013).
<b>Stochastic discount factor:</b>	The discount factor that is a function of the investment returns. This factor discounts both share returns and investment returns equivalently (Cochrane, 1996).
<b>Subsequent share return:</b>	The change in the market equity value of the firm over a period.
<b>True value:</b>	The rationally expected present value of the cash flows of the firm that are discounted at the appropriate rate (Alti & Tetlock, 2014).
<b>Q-ratio:</b>	The ratio of the market value of an asset to its replacement value (Brainard & Tobin, 1968; Cochrane 1991, 1996; Tobin, 1969).
<b>Value firms:</b>	Firms with high book-to-market ratios are referred to as “value firms” (Anderson & Garcia-Feijóo, 2006, p.172).

**Volatility:** The variation, dispersion or deviation of the returns of an asset from their mean. Annualised volatility is based on the daily closing volatility over the previous year (Iress, 2018).

## **1.8 Organisation of the thesis**

Chapter 1 highlights the problems with traditional asset-pricing models that fail to explain the negative I–R relationship, and the need to look at a new approach (IBAPT). The new approach integrates both the firm and the market sides, instead of just looking at the demand side as per previous asset-pricing studies that have dominated literature.

Chapter 2 shows the distinctiveness and relevance of the current South African study context. Chapter 3 presents a critical review of the literature, giving particular attention to the debate about the contrasting rational and behavioural explanations for the negative I–R relationship. The IBAPT which directly relates share return to firm investment, and which is the anchor of this study is presented in Chapter 3. The conceptual model was based on IBAPT, complemented by the other rational-based literature discussed in Chapter 3. Three main hypotheses are formulated from the conceptual model. Hypothesis 1 relates to the association between I–R, investment and lag periods; hypothesis 2 relates to the significance of the negative I–R relationship; and hypothesis relates to the association between I–R and abnormal effects. The behavioural contrasting theory is described and discussed in this thesis, but was not tested in the current research.

The researcher managed to access data and research software, which was difficult and costly to obtain, for the developing market context. This is discussed in Chapter 4. The research procedures to test these three hypotheses are presented in Chapter 4. Chapter 5 presents the results of testing the three hypotheses. To test hypothesis 1 and hypothesis 2, two measures were used for firm investment (linear and LOGEST). Two methods – a bootstrapping method using the style engine and paired-t tests with bootstrapping functionality using the IBM SPSS software platform was used to test hypothesis 2. Cases were modelled with different investment and lag periods, which were used to test hypothesis 3. Chapter 6 reports the results, foregrounding the importance of the significance of the negative I–R relationship, and the importance of including the investment and lag periods to the theory. Chapter 7 concludes, showing the relevance and utility of the study. The study advanced IBAPT and, in this section, the researcher suggests a number of future research opportunities.

## **Chapter 2: Context**

The context of the study is described in this chapter. The IBAPT was developed in the United States, characterised by developed market conditions of low-volatility, and high-turnover conditions. The South African economy and the JSE are distinctively different from the situation in the United States, with high-volatility, risky, and low-turnover conditions, discussed in this chapter. Titman et al. (2013) relates higher arbitrage costs and lower market efficiency to higher volatility and lower turnover market conditions. This means that the costs of arbitrage are high and therefore the market would not be efficient, as compared to the US, meaning that the rational IBAPT may not hold (discussed in Chapter 3).

### **2.1 The South African developing market context**

South Africa has been defined as a developing market (The World Bank, 2017). During the study period, the country experienced sanctions, major political change, change from an inward-focussed economy to an open and liberally integrated economy globally, economic growth spurts and two severe market crashes resulting from global financial crises which resulted in the high-volatility and high-risk market characteristics detailed in the sections below.

During the years preceding 1994, South Africa was described as 'inward-focussed' (Financial Times, 2017; Marketline, 2017; The World Bank, 2017), largely as a result of the sanctions imposed against the country for its apartheid policies. In 1990, after many years of political unrest, Nelson Mandela was released after 27 years of imprisonment and the party he led, the African National Congress (ANC), was unbanned (Financial Times, 2017; Marketline, 2017; The World Bank, 2017). A year later, US sanctions were lifted (Financial Times, 2017; Marketline, 2017; The World Bank, 2017), legitimising foreign trading on the JSE.

In 1994, South Africans voted in the country's first multi-racial democratic elections, and under Mandela's leadership began to confront the challenges of addressing previous inequalities and establishing a multi-racial society (Financial Times, 2017; Marketline, 2017; The World Bank, 2017). South Africa re-entered the global economy with market-driven policies and achieved steady progress in the first decade under its new constitution (Financial Times, 2017; Marketline, 2017; The World Bank, 2017). Between 1994 and 1999, following the lifting of sanctions, an inflow of foreign direct investment (FDI) was noted, resulting in positive growth in subsequent years (Financial Times, 2017; Marketline, 2017; The World Bank, 2017).

In the years 1994 to 2008, the average annual growth rate of the gross domestic product (GDP) was 3.6%, quarter on quarter annualised (Statistics South Africa [Stats SA], 2018). During this period,



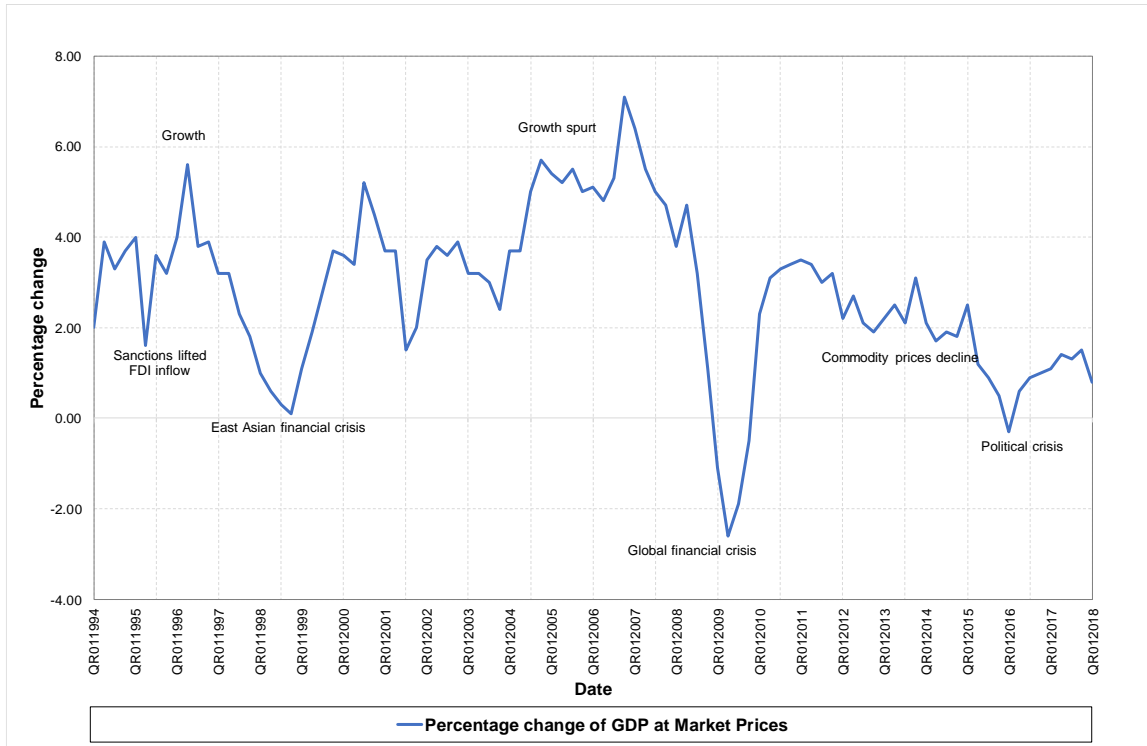
the demand for commodities was high (Financial Times, 2017; Marketline, 2017; The World Bank, 2017). However, during the years 1997–1998, when the East Asian financial crisis occurred (Financial Times, 2017; Marketline, 2017; The World Bank, 2017), the average annual GDP growth rate dropped to 1.5%, quarter on quarter annualised (Stats SA, 2018), and there was a downturn in the economy.

Open market structural adjustments were made to re-integrate South Africa into the global economy (Financial Times, 2017; Marketline, 2017; The World Bank, 2017). Between 2000 and 2001, the global dot-com bubble burst (Financial Times, 2017; Marketline, 2017; The World Bank, 2017), resulting in an increase in market volatility conditions.

During the three-year period 2005 to 2007, the economy improved, with annualised GDP growth rates averaging 5.4% quarter on quarter over the period (Stats SA, 2018). At that stage, South Africa was an extremely open economy (Financial Times, 2017; Marketline, 2017; The World Bank, 2017), and the global financial crisis therefore affected the economy. The subprime mortgage crisis of 2007–2009 in the United States had a damaging effect, and average growth was negative for 2009 (Stats SA, 2018), with average annual GDP growth in 2009 down -1.5% quarter on quarter annualised (Stats SA, 2018). Yet despite the global financial crisis, the institutional environment (especially in terms of its financial structure) was strong, and this kept the South African economy intact.

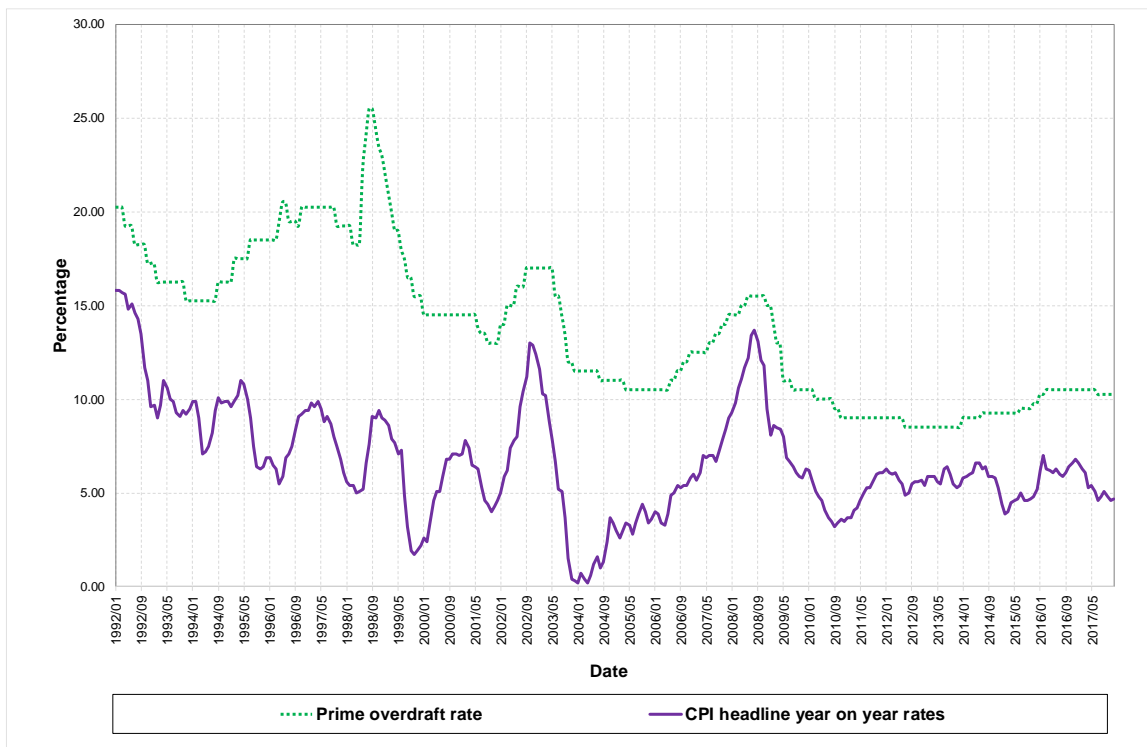
Between 2010 and 2017, average GDP growth rate was 2.0% quarter on quarter annualised (Stats SA, 2018). South Africa remained susceptible to the business cycles of commodity prices, and received credit rating downgrades in 2016 and 2017, with a low-growth economy, high political uncertainty, and social and economic inequality still posing challenges (Financial Times, 2017; Marketline, 2017; The World Bank, 2017).

GDP growth over the period is shown in Figure 2.1; and the interest rate (prime overdraft rate) and inflation (consumer price index: CPI) trends are shown in Figure 2.2. The interest rate in South Africa averaged 12.4% between 1998 and 2017. However, this 20-year average masks major fluctuations: it reached the very high level of 25.5% in August 1998, and the relatively low level of 8.5% in July 2012 (South Africa Reserve Bank [SARB], 2018).



**Figure 2.1: South African GDP annual growth rate (quarter on quarter annualised)**

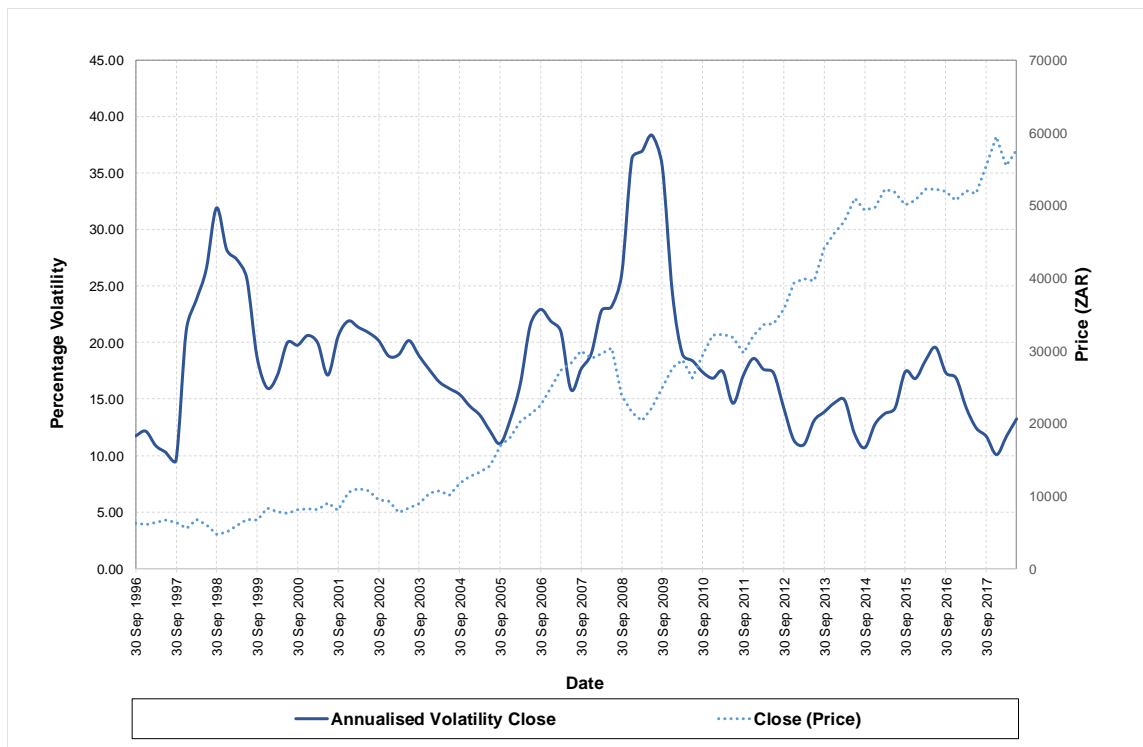
**Source: Stats SA (2018)**



**Figure 2.2: South African interest rate and inflation trend**

**Source: SARB (2018), Stats SA (2018)**

The volatility and price trend of the J203 All Share Index over the period 30 September 1996 to 30 June 2018 is shown in Figure 2.3. The indexes are not dividend adjusted. The volatility is determined by multiplying the standard deviation of the daily price returns by an annualised factor based on the number of trading days during the historical year for which the volatility is measured (Iress, 2018). Volatility was persistently high. It was at its highest in the 2008–2009 period during the global financial crisis. High volatility was related to the economic, social and political uncertainty in the country, which created uncertainty and unpredictability in the market for investment (Rehman, Kamal, & Amin, 2017).



**Figure 2.3: Volatility and price trend of the J203 (All Share Index)**

**Source: Iress (2018)**

## **2.2 Difference between the South African and United States markets**

The difference and relevance of the difference between the South African and United States markets are discussed in this section. A developing market presents an institutional and economic environment, which is weaker in several respects than that of developed markets (The World Bank, 2018). The South African market is significantly smaller than that of the United States, with fewer market participants, lower liquidity, lower turnover and higher trading costs (see Table 2.1). The South African market is driven by a small number of specialised institutional investors who own and

manage much of the assets on the JSE (Harper, 2017). As also noted in Semnarayan et al. (2018) all these factors combine to intensify trading frictions and raise the costs of arbitrage. Table 2.1 below (extracted from the World Bank databank [2018]) represents these differences, averaged over the period 1988 to 2017.

**Table 2.1: Indicators of market development and level of arbitrage (average over the period 1988 to 2017)**

Parameter	United States	South Africa
GDP (current US\$ billion)	11 668	223
GDP per capita (constant 2010 US\$)	44 665	6 460
Listed domestic companies, total	5 774	487
Market capitalisation of listed domestic companies (% of GDP)	112	194
Market capitalisation of listed domestic companies (current US\$ billion)	14 088	481
Shares traded, total value (current US\$ billion)	21 972	126
Shares traded, total value (% of GDP)	162	45
Shares traded, turnover ratio of domestic shares (%)	137	21

**Source: The World Bank (2018)**

The behaviour theorists use the parameters in the above table (Table 2.1) to compare the relative level of arbitrage costs between markets, in previous literature (Alti & Tetlock, 2014; Lam & Wei, 2011; Li & Zhang, 2010; Titman et al., 2013). These parameters are related to the level of risk or costs in making transactions (trading frictions). Based on these variables, behaviour theorists would classify this context as one with high arbitrage costs (or high limits to arbitrage) (discussed in section 3.3). The level of arbitrage costs is higher in South Africa as compared to the United States. The South African developing market context is characterised by higher risk conditions, lower turnover, higher volatility, higher transaction costs and higher information asymmetry than the US developed market context (Financial Times, 2017; Iress, 2018; Marketline, 2017; SARB, 2018; Stats SA, 2018; The World Bank, 2017, 2018).

The IBAPT was developed in the United States, with a developed market context. Zhang (2017) further proposed that the IBAPT should be tested in markets other than the United States. The majority of previous studies on the I–R relationship was concentrated on the United States, extensively exhausting the United States data. From the IBAPT perspective, Zhang (2017) also argues that the IBAPT is not a risk-based theory, and that there is no need to relate this to the

efficiency of markets. However, this proposition was not fully tested by Zhang (2017), who also suggested that this should be the subject of further research. The current study was done in a developing market context, with high-risk, low-turnover, and high-volatility, which is also distinctively different from previous studies in this area, and which provided an appropriate and new environment for further testing and development of the nascent IBAPT.

### Chapter 3: Literature review

Firms should create and maximise economic value for the firm and shareholders. Thus, it could follow that there should be a positive association between firm investment and subsequent shareholder return. The foundation of firm investment literature is that companies (firms) should invest in positive NPV projects, as this should increase the value of the firm for the shareholders by the quantum of the NPV. This is demonstrated in the fundamental discounted cash flow Equation 3.1 below (McCallum, 1992), where NPV represents the net cash flow of the investment, discounted to the present value by the capital cost of the investment. Firms that undertake positive NPV projects should out-perform those that do not invest, and consequently firms with higher rates of investment should have higher subsequent shareholder returns than firms with lower rates.

#### Equation 3.1: The discounted cash flow (DCF) equation

$$NPV_{t=0} = \sum_{t=1}^T \frac{C_t}{(1+r)^t} - Cost_{t=0}$$

Where:

- NPV = net present value of the investment
- $C_t$  = future net real cash flow of the investment
- T = life of the investment
- r = cost of capital
- Cost = present value of cash expended for the investment at  $t = 0$

Instead, multiple previous studies (such as Alti & Tetlock, 2014; Anderson & Garcia-Feijóo, 2006; Berk et al., 1999; Cooper et al., 2008; Cooper & Priestley, 2011; Cordis & Kirby, 2017; George et al., 2018; Hou et al., 2015; Lam & Wei, 2011; Li & Zhang, 2010; Lin, Li & Yuan, 2018; Lipson, Mortal, & Schill, 2011; Mortal & Schill, 2015; Peters & Taylor, 2017; Song, 2016; Stambaugh & Yuan, 2017; Titman, Wei, & Xie, 2004; Titman et al., 2013; Xing, 2008; Zhang, 2017) discussed in this chapter have found that there is a strong negative relationship between investment by a firm and subsequent shareholder return on US data.

Equally numerous are the diverse and competing explanations for this negative relationship (see, for example, Alti & Tetlock, 2014; Anderson & Garcia-Feijóo, 2006; Berk et al., 1999; Cooper & Priestley, 2011; Cooper et al., 2008; Cordis & Kirby, 2017; George et al., 2018; Hou et al., 2015; Lam & Wei, 2011; Li & Zhang, 2010; Lin et al., 2018; Lipson et al., 2011; Mortal & Schill, 2015; Peters & Taylor, 2017; Song, 2016; Stambaugh & Yuan, 2017; Titman et al., 2004; Titman et al., 2013; Xing, 2008; Zhang, 2017) discussed in this chapter.

Debate also exists about whether the negative I–R relationship is significant and pervasive across all markets and firm sizes (Fama & French, 2008; Lipson et al., 2011; Titman et al., 2013). Titman et al. (2013) argue that the negative I–R relationship would only be significant in developed markets and not in developing markets, based on the rational risk explanation. According to Titman et al. (2013), rational assumptions will not hold in developing markets because such markets are inefficient and irrational. Fama and French (2008) maintain that the negative I–R relationship is only found in micro-sized and small firms, and is absent in large firms. Kumar and Li (2016) claim that the I–R relationship depends on the type of investment.

The anchor for this study was the rational IBAPT, discussed in section 3.1, which directly relates firm investment to share return, based on optimal investment principles (Zhang, 2017). The investment CAPM and q-factor model which relates expected share return to firm-level variables (see Cochrane, 1991, 1996; Cooper & Priestley, 2016; Cordis & Kirby, 2017; George et al., 2018; Hou et al., 2015; Liu et al., 2009; Zhang, 2017), were developed on the IBAPT and are presented in section 3.1.

Evidence is mounting that the more fundamental aspects of traditional asset-pricing may be flawed (Zhang, 2017). Although practitioners widely use the basic CAPM, which is an example of a consumption-based asset-pricing model (Zhang, 2017) for determining firm valuations and predicting share returns, the basic CAPM has been empirically shown to be poor in predicting expected share returns (Berk et al., 1999; Cochrane, 1991, 1996; Fama & French, 1992, 1993, 2004, 2008; Li, Livdan, & Zhang, 2009; Liu et al., 2009; Ward & Muller, 2012). This consumption-based asset-pricing literature is discussed in section 3.2. The IBAPT offers a new approach that overcomes the problems with the consumption-based approach (see Cochrane, 1991, 1996; Cooper & Priestley, 2016; Cordis & Kirby, 2017; George et al., 2018; Hou et al., 2015; Liu et al., 2009; Zhang, 2017).

Prominent empirical asset-pricing models formulated on market data observations are discussed in section 3.2.4, and the IBAPT is related to these empirical models. Additional schools of thought related to the risk-based explanations are discussed as follows: real options literature, relating current and growth options to share return in section 3.2.2; and the macroeconomic risk explanation in section 3.2.3. Consumption-based asset-pricing is analogous to IBAPT under ideal equilibrium conditions (Zhang, 2017). The contrasting behavioural explanation of overinvestment and mispricing premised on the limits to arbitrage theory is reviewed in section 3.3. The hypotheses for the study were formulated on extending the IBAPT, and are presented in section 3.5.

### 3.1 Investment-based asset-pricing theory (IBAPT)

The theoretical anchor of this thesis is the nascent investment-based asset-pricing theory (IBAPT). The concept of relating firm investment to expected share return was initially conceptualised by Cochrane (1991) but gained impetus as an asset-pricing theory recently with Hou et al. (2015) and Zhang (2017). The IBAPT is based on the traditional q-theory (discussed in section 3.2.1), but relates share return to the supply (or firm) perspective (see Cochrane, 1991, 1996; Cooper & Priestley, 2016; Cordis & Kirby, 2017; George et al., 2018; Hou et al., 2015; Liu et al., 2009; Zhang, 2017).

The IBAPT differs from traditional q-theory (termed the q-theory of consumption), which relates expected share returns to the demand (or market) perspective (discussed in section 3.2.1). Traditional q-theory is consumption-based, whereas the IBAPT is based on relating the production variables of the firm to share return, and is investment-based. The production-based model ties share returns directly to the production variables of production output and firm investment (Cochrane, 1991). Further development followed, culminating in the investment CAPM equation (Equation 3.3) and the q-factor asset-pricing model (Equation 3.4), relating expected share return to two factors – firm investment and expected profitability.

The principle of optimal investment, follows from the neoclassical Modigliani and Miller's assertion (1958, p.262) that "an asset is worth acquiring if it increases the value of the owners' equity, i.e., if it adds more to the market value of the firm than the costs of acquisition." Investment is made as long as the returns exceed the cost of capital; if they do not, the firm will not invest (Modigliani & Miller, 1958, proposition III, p.262). From this foundational literature, it is already possible to discern an inference that firms will invest up to the level of their expected share returns. The optimal investment principle is that the marginal costs of investment must equal the marginal benefits of investment, and that firms optimise investment to maximise the value of their market equity (Zhang, 2017).

The optimal investment principle was used by Cochrane (1991) to derive the investment return equation (Equation 3.2). Other key assumptions used to derive the investment return equation include:

- the firm produces a single homogenous commodity and liquidates after the commodity is consumed;
- the investment return is the rate at which the firm transforms goods from date  $[t]$  to date  $[t+1]$ ;
- investment returns at firm level are equal to discount rates at firm level; and
- debt and taxes are ignored.



If there is an increase in output, share prices will rise, and if share prices rise, firms should raise investment immediately, since the price has risen relative to the cost of capital (Cochrane, 1991). Investment growth and hence the investment return from the last period will then rise simultaneously with the increased share return: investment return moves together with share return (Cochrane, 1991). From this relationship of production variables to share return, Cochrane (1991) derives that share return equals the investment return of the production process, made possible through arbitrage: “the investment return is the same as the return on a share of the firm” (Cochrane, 1991, p.218).

Cochrane (1991) derives the investment return equation over period [t] to the next [t+1], as shown in Equation 3.2.

**Equation 3.2: Cochrane’s (1991) investment return equation**

$$R(t \rightarrow t + 1) = (1 - \delta) \left( mp_{t+1} + \frac{1 + \alpha \left( \frac{I_{t+1}}{k_{t+1}} \right)^3}{1 - \left( \frac{3}{2} \right) \alpha \left( \frac{I_{t+1}}{k_{t+1}} \right)^2} \right) \left( 1 - \frac{3}{2} \alpha \left( \frac{I_t}{k_t} \right)^2 \right)$$

Where

$R(t \rightarrow t + 1)$	=	investment return over one period of time
$\delta$	=	depreciation rate
$mp_t$	=	the marginal productivity of capital
$\alpha$	=	the adjustment cost parameter (positive)
$I_t$	=	investment
$k_t$	=	capital

Based on Equation 3.2, if the investment / capital ratio  $[I_t/k_t]$  at time [t] is high, the investment return is low. From Equation 3.2, investment is high when returns are low. Mathematically, the investment return equation (Equation 3.2) is the equivalent of the marginal-q (see section 3.2), restated from the perspective of the firm (Cochrane, 1991). Cochrane (1991) shows empirically that the average investment return at firm level matches the average share returns on the stock market and that the investment-to-capital ratio predicts share return with a significantly negative slope.

Liu et al. (2009) demonstrate that this relationship also holds when debt and taxes are included in the model. Liu et al (2009,) expand Cochrane’s (1991) investment return equation and derive the levered investment return equation which states that “levered investment returns equal stock returns for every stock, every period, and every state of the world” (Liu et al, 2009, p.1110). Liu et al. (2009) conclude that the portfolios of firms align their investment with the costs of capital in the presence of debt and taxes, and that this alignment explains the relationship between investment and share

return. In this case, including debt and taxes, the expected share return and the leveraged investment return are equal. Without leverage, the weighted average of share return is equivalent to the weighted average cost of capital (Liu et al., 2009). Liu et al. (2009) explain the reason for the negative I–R relationship, based on the IBAPT: “Because investment today increases with the net present value of one additional unit of capital and because the net present value decreases with the cost of capital, a low cost of capital means high net present value and high investment. As such, investment today and average stock returns are negatively correlated.” (Liu et al., 2009, p.1123).

The investment CAPM equation (Equation 3.3) is based on assumptions of rational firms and markets, and on the optimal investment principle. The investment CAPM equation is derived from Cochrane (1991) and Liu et al. (2009) investment returns equation, from the production (or firm) perspective, and on the principle that firms invest in such a way that investment returns equal share returns. In a two-period model (Equation 3.3), expected share returns are a function of current investment and expected profitability (Liu et al., 2009; Hou et al., 2015; Zhang, 2017).

The derivation of the investment CAPM (two-period model) Equation 3.3 is shown in Zhang (2017, p.546–547). The model is built on the following production variables:

- Firm [i] starts with productive capital [ $K_{it}$ ] at date [t] and exits at [t+1]. The capital depreciation is 100% between [t] and [t+1].
- [ $K_{it}$ ] and profitability [ $X_{it}$ ] are known at [t].
- The operating profits  $\pi_{it} \equiv X_{it} K_{it}$ .
- Profitability [ $X_{it+1}$ ] is stochastic.
- [ $I_{it}$ ] is the investment for date [t], then [ $K_{it+1} = I_{it}$ ].
- [ $X_{it+1}$ ] is the marginal productivity of capital.

### Equation 3.3: The two-period investment CAPM equation

$$r_{it+1}^S = \frac{X_{it+1}}{1 + a\left(\frac{I_{it}}{K_{it}}\right)}$$

Where

Firm	=	i
$r_{it+1}^S$	=	the share return of firm i
$K_{it}$	=	capital at date t
$X_{it+1}$	=	profitability at date t + 1
$I_{it}$	=	investment for date t
$a$	=	constant parameter > 0

The investment CAPM shows that – the firm keeps investing until the marginal costs of investment  $[1 + a(I_t/K_t)]$  at date  $[t]$ , equals the marginal benefits of investment  $[X_{t+1}]$  at date  $[t + 1]$  discounted to date  $[t]$  with the share return  $[r_{t+1}^s]$  as the discount rate. Equivalently, the ratio of the marginal benefits of investment at date  $[t + 1]$  divided by the marginal costs of investment at date  $[t]$  equals the discount rate  $[r_{t+1}^s]$ , cross-sectionally (Zhang, 2017).

According to the investment CAPM equation (Equation 3.3), expected share returns are connected to firm characteristic variables of firm investment and expected profitability. According to the investment CAPM equation (Equation 3.3), lower share returns is associated with higher firm investment and lower expected profitability; and higher share returns is associated with lower firm investment and higher expected profitability. The investment CAPM is consistent to the DCF equation (Equation 3.1) according to Zhang (2017). Firm investment predicts share returns because high costs of capital imply low NPVs of new capital and low investment, while low costs of capital imply high NPVs of new capital and high investment (Zhang, 2017).

Similarly, Liu et al. (2009) also derived the multi-period investment CAPM. The difference between the multi-period investment CAPM and two-period investment CAPM is that time is discrete and the horizon infinite in the multi-period model. In the multi-period model, (with debt and taxes), Liu et al. (2009) show that expected share returns are a function of current investment, expected profitability, and expected investment growth.

This marks a major change in asset-pricing methodology, where the investment CAPM expresses share return as a function of firm-level variables only (Zhang, 2017). The investment CAPM shows that firm characteristics are sufficient to predict expected share returns. The investment CAPM does not use consumption or demand-based variables (Zhang, 2017).

This further means that consumption betas (as per the consumption CAPM discussed in section 3.2.1) do not affect expected share returns, when firm characteristics are properly related to share return (Zhang, 2017). According to the IBAPT, firms align their investment policies with their costs of capital, and this alignment drives the abnormal effects that would be have classified as anomalous in terms of the consumption CAPM (Zhang, 2017). The failures of the consumption-based asset-pricing models are discussed in section 3.2. Many anomalies that would have been explained only by behavioural finance and mispricing (see section 3.3), can be explained by the investment CAPM (Zhang, 2017). Based on the investment CAPM, share return is directly related to firm investment, and negatively.

Hou et al. (2015) derive and implement the HXZ model (Equation 3.4) based on the investment CAPM. Hou et al. (2015) examined 80 ‘anomalies’ previously documented and found that firm investment and expected profitability explain nearly all the significant anomalies. Based on this, they derived the ‘q-factor asset-pricing model’ (or HXZ model), which uses the firm investment and expected profitability (return on equity [ROE]) factors from the investment CAPM as the primary factors.

**Equation 3.4: The q-factor asset-pricing model (or ‘q-factor model’ or ‘HXZ model’)**

$$E[r^i] - r^f = \beta_{MKT}^i E[MKT] + \beta_{ME}^i E[r_{ME}] + \beta_{\frac{I}{A}}^i E\left[\frac{r_I}{A}\right] + \beta_{ROE}^i E[r_{ROE}]$$

The expected share return premium (returns in excess of the risk-free rate ‘ $E[r^i] - r^f$ ’) is related to four factors in the HXZ model:

- the market excess return (market factor ‘MKT’);
- the difference between the return on a portfolio of small-size firms and the return on a portfolio of big-size firms (size factor ‘ $r_{ME}$ ’);
- the difference between the return on a portfolio of low-investment firms and the return on a portfolio of high-investment firms (investment factor ‘ $r(I/A)$ ’);
- and the difference between the return on a portfolio of high-profitability firms and the return on a portfolio of low-profitability firms (expected profitability factor ‘ $r_{ROE}$ ’) (Hou et al., 2015).

**On the market factor** – the market factor in the q-factor model sets the time-series movement of expected share returns over the period. The other factors in the model determine the cross-sectional differences between the portfolios (Hou et al., 2015).

**On the size effect** – a size factor is included in the q-factor model; however, Hou et al. (2015) state that they include this factor to improve the utility of the q-factor model in evaluating mutual funds, where size is a significant factor. They (Hou et al., 2015) further demonstrate that the incremental role of size is minimal for listed firms.

**On the expected profitability factor** – according to the q-factor model, firms with high expected profitability (ROE) earn higher expected returns than firms with low expected profitability, consistent to the investment CAPM. The ROE factor is the main source for capturing anomalies in the momentum and profitability categories (Hou et al., 2015). Expected profitability is excluded in the scope of this study.

**On the firm investment factor** – according to the q-factor model, firms with high investment earn lower expected share returns than firms with low investment. The investment factor captures anomalies in the value-versus-growth and investment categories (Hou et al., 2015). A combination of the investment and expected profitability factors allows the q-factor model to capture anomalies in other categories (Hou et al., 2015). The value-versus-growth effect is discussed below. Equity issuance, debt-to-market equity and profitability that falls in the investment categories are discussed below.

**On the value-versus-growth effect** – Hou et al. (2015) argue that the Fama and French factors in their three-factor model (Equation 3.7) might be noisy assumptions of the q-factor model. Value-versus-growth is therefore not specifically included as a separate factor in the q-factor asset-pricing model, contrary to the five-factor model of Fama and French (2015) (discussed in section 3.2.4). The value-versus-growth premium is consistent with the investment premium from the investment CAPM model (Hou et al., 2015). From the investment CAPM model, Zhang (2017) shows that the marginal costs of investment  $[1 + a(I_{it}/K_{it})]$  equals market equity-to-capital  $[P_{it}/K_{it+1}]$ . Without debt,  $[P_{it}/K_{it+1}]$  equals market-to-book equity. Value firms with low  $[P_{it}/K_{it+1}]$  invest less and earn higher expected returns than growth firms with high  $[P_{it}/K_{it+1}]$ . Conversely, firms with high market-to-book ratios invest more and earn lower expected returns than firms with low market-to-book ratios.

**On the equity issuance effect** – Cooper et al. (2008) observe that firm investment events, such as acquisitions, equity issuance and increased borrowings, are followed by periods of abnormally low share returns; and firm divestment events such as share repurchases, dividend payouts and debt repayments, are followed by periods of abnormally high share returns (Cooper et al., 2008). Lyandres, Sun and Zhang (2008) found that the investment factor helps interpret the “new issues puzzle” [Lyandres et al., 2008, p.2826]. According to Li et al. (2009) and Lyandres et al. (2008), equity-issuing firms are disproportionately high-investment firms, based on the flow of funds constraint (that the uses of funds should equate to the source of funds). Capital raising (such as equity issuance) is associated to higher investment (and consequently lower share returns), and capital distribution (such as dividends issue) is associated with lower firm investment (and consequently higher share returns) (Li et al., 2009; Lyandres et al., 2008). Therefore, based on the balance-sheet constraint of firms, equity issuers earn lower returns than non-issuers (Lyandres et al., 2008). Lyandres et al. (2008) also found that the investment factor explains the abnormal effects following initial public offerings, seasoned equity offerings, convertible debt offerings, and composite issuance.

**On the debt-to-market equity effect** – the proponents of behavioural explanations (such as Lipson et al., 2011) emphasise that idiosyncratic volatility (IVOL) is a necessary requirement for the negative

I–R relationship (discussed in section 3.3). Kumar and Li (2016), however, propose an alternative explanation for the negative IVOL–return relationship, positing that IVOL is related to growth options. These scholars (Kumar & Li, 2016) suggest that firms with higher debt-to-market equity ratios effectively shift risk to the lenders, to the benefit of their shareholders. According to Kumar and Li (2016), the risk-shifting view (Cao et al., 2008) implies that the managers of levered firms exercise growth options that increase the idiosyncratic risk (or IVOL) of the firm. The cost of higher IVOL is borne by the lenders. This reduces the risk of equity and increases the market equity value of the firm, benefiting shareholders, consistent with optimal investment principles. Through this process shareholders benefit from higher equity value and lower risk of equity (Kumar & Li, 2016). This results in the negative IVOL–return relationship, and is consistent to the negative I–R relationship.

**On the profitability effect** – the profitability effect is the observed abnormal effect in the market where firms that have experienced higher profitability show lower subsequent share returns than firms that have experienced lower profitability. Based on the IBAPT (Zhang, 2017), the investment factor should be stronger among firms with higher cash flows than among firms with lower cash flows. Titman et al. (2004) find that the negative I–R relationship is stronger with firms that had higher cash flows than firms that had lower cash flows. Titman et al. (2004) interpret this as behavioural, relating to higher investment discretion by managers of firms with higher cash flows than firms with lower cash flows; and investors underreacting to managers investing for their own benefit rather than the benefit for shareholders. However, IBAPT, derived without behavioural biases, is consistent with the evidence that the investment factor is stronger in firms with higher cash flows than lower cash flows, according to Zhang (2017).

Researchers have recently started to apply the investment CAPM and q-factor model to different situations. Cooper and Priestley (2016) report on applying the investment CAPM as a valuation model of private firms in the United States. Estimating the costs of capital from the consumption CAPM (first developed by Rubinstein [1976], Lucas [1978], and Breeden [1979]) requires historical share return data, which is not feasible for private firms (Zhang, 2017). This is not required for the investment CAPM, as costs of capital can be estimated directly from firm-level variables (Cooper & Priestley, 2016; Hou et al., 2015; Zhang, 2017). As such, the investment CAPM is uniquely appropriate for valuation of private firms, as it is not dependent on consumption betas determined from the market (Cooper & Priestley, 2016; Hou et al., 2015; Zhang, 2017).

Cooper and Priestley (2016) compare the valuation determinants of private to public firms. They (Cooper & Priestley, 2016) found that characteristics, such as firm investment and expected profitability directly relate to the cross-section of investment returns across private firms, similar to that found for public firms by Liu et al. (2009) and Hou et al. (2015). Private firms do not have share

prices to which biased investors could over- or underreact to, and therefore should be less affected by mispricing. Cooper and Priestley (2016) formulated a four-factor model for both private and public firms, on the same basis as the q-factor model. Their (Cooper & Priestley, 2016) model could be used to determine the cost of capital of private firms, and determine investment returns.

Cordis and Kirby (2017) applied the two-period model of the investment CAPM on data (dated July 1963 to December 2012) from the NYSE, the AMEX and the NASDAQ firms. These scholars (Cordis & Kirby, 2017) measured firm investment as net investment to the capital of the firm and found that the slope of the function relating share returns to firm investment was quadratic (consistent with findings by Liu et al. [2009] and Hou et al. [2015]). They (Cordis & Kirby, 2017) found that the I–R relationship was negative at low investment levels, close to zero at intermediate investment levels and negative at high investment levels. Following on from Cochrane (1991), Cordis and Kirby (2017) derived mathematically that firms invested based on their cost of capital (which is equivalent to share return). This is consistent with the two-period model of the investment CAPM, where each firm sets its hurdle rate equal to its expected share return, and chooses its net investment to the capital of the firm, such that the NPV of the last unit of investment is zero, resulting in a negative I–R relationship (Cordis & Kirby, 2017).

George et al. (2018) empirically compared the q-factor model against other models, such as the Fama and French (2015) five-factor empirical model in the capturing of the price-to-high (PTH) anomaly. PTH refers to the ratio of the current share price to the high price over a 52-week period (George et al., 2018). The PTH anomaly is where high PTH shares earn premium share returns (George et al., 2018). George et al. (2018) found that the q-factor model explains this anomaly better than other models, and they also found a significant relationship between PTH and future profitability and future investment growth as per the multi-period investment CAPM.

These authors (George et al., 2018) maintain that their results indicate that firms align their investment policies with their cost of capital and suggest that expected investment growth explains the cross-sectional relationship between firm characteristics and expected share returns. They further suggest that expected investment growth should be incorporated into asset-pricing models, which would then be able to account for a wide range of anomalies (George et al., 2018). George et al. (2018) found the q-factor model helps to explain other anomalies observed in the market – specifically the price-to-high anomaly is related to I–R, which they interpret as consistent with the IBAPT.

Cochrane (1991) and Liu et al. (2009) conceptualise and show that firm investment and share returns are directly related, where investment returns at firm level are equal to share returns at market level.

This is the foundation of the IBAPT. The IBAPT is based on rational optimal investment principles, where firms invest to maximise their market value of equity. Firms continue investment as long as their investment returns are above their cost of capital. Their cost of capital is equivalent to their share returns. The investment CAPM equation is formulated on these principles and shows that firm investment and share return are directly related, negatively. Hou et al. (2015) expand the investment CAPM. They formulate an asset-pricing model and show that the investment factor in their model is related to value-versus-growth and investment effects observed in the market. Cooper and Priestley (2016) further confirm utility of the IBAPT and the related investment CAPM and q-factor asset-pricing models as it could also be applied to private firms. Cordis and Kirby (2017) confirm that the I–R relationship is negative, and quadratic. George et al. (2018) show that this fundamental model can be generically applied, as it could also explain other effects in the market, not originally studied by Hou et al. (2015) when formulated. The IBAPT directly relates share return to firm characteristics, and the current research tested and extended this theory.

## **3.2 Risk-based models**

Rational risk-based asset-pricing relates expected share return to risk. The researcher categorised these into consumption-based asset-pricing, real options models and the prominent empirical asset-pricing models. IBAPT was conceptualized on the consumption-based traditional q-theory, but looking at asset-pricing from the firm side. The real options model explains the I–R relationship by modelling the risk of the firm. The empirical asset-pricing literature has evolved to the Fama and French (2015) five-factor model that now incorporates the investment factor, which was developed in parallel to the IBAPT.

### ***3.2.1 Consumption-based asset-pricing***

The IBAPT was conceptualised from the traditional consumption-based q-theory and is mathematically analogous to this theory (Zhang, 2017). The IBAPT addresses empirical problems with consumption-based asset-pricing discussed here.

The traditional q-theory was initially formulated by Brainard and Tobin (1968), and Tobin (1969) who used a consumption-based asset-pricing model for modelling expected share returns. ‘Consumption-based’ indicates a market or demand perspective rather than a firm or production perspective. ‘Investment-based’ refers to the firm perspective. Brainard and Tobin (1968) and Tobin (1969) modelled expected returns from the perspective of the market, employing factors from the market side to predict expected return.



According to the traditional q-theory of consumption, investment is stimulated when capital commands a value in the market higher than its production cost, while investment is discouraged when the market value of the capital of the firm is less than its replacement cost. An alternative formulation is that investment is stimulated when the market yield on equity is low relative to the investment returns. According to the consumption q-theory, investment is thus positively associated with the ratio of market value to replacement costs ( $q$ ) (Brainard & Tobin, 1968; Tobin, 1969). Brainard and Tobin (1968) explain that there is an inverse relationship between the market value of equity and the return it bears. The product between the market value of equity and its return equals the marginal productivity of capital.

The basic CAPM is a consumption-based asset-pricing model, employing factors from the demand or market side (market risk premium) to determine expected share return (Zhang, 2017). Consumption-based asset-pricing dominates asset-pricing literature (Zhang, 2017), but Zhang (2017) argues that consumption-based asset-pricing has failed empirically. Many observations have been termed market ‘anomalies’ because they cannot be explained by these consumption-based models, especially the consumption CAPM which extends the CAPM and uses a consumption beta (based on consumption growth) instead of the market beta (Zhang, 2017). This raised doubts on the premise of efficient markets, and provoked behavioural explanations for the market observations. Zhang (2017) further argues these ‘anomalous’ observations are not the results of market inefficiency or behavioural biases. Rather, ignoring firms renders the consumption-based asset-pricing models incapable of generating empirical explanations for these ‘anomalies’. From a finance and economics perspective, it is fundamentally important to incorporate the firm side (Zhang, 2017).

As noted in Chapter 1, the failure of the consumption CAPM is partly attributable to its refusal to consider the firm (Zhang, 2017). The main cause for the problems with the consumption CAPM is that it is derived from the principle of the representative consumer which is determined from the average of all consumers in the market, according to Zhang (2017). Zhang (2017, p.584) terms this an “aggregation problem”, where the preferences of all consumers in the market are aggregated and averaged to represent the individual rational consumer. In reality, the aggregate behaviour of the market may be neither rational nor representative (Zhang, 2017). Zhang (2017) further argues that an individual consumer may be rational, but collective aggregated behaviour cannot be assumed to operate in the same way. By contrast, the investment CAPM, is derived from the principle of an individual firm; thus it does not have an aggregation problem (Zhang, 2017).

The foundations of IBAPT are analogous to the traditional q-theory, mathematically. The consumption-based models, mainly the basic CAPM (discussed further in section 3.2.4), have dominated extant asset-pricing literature. However, the consumption-based model has been weak

empirically, mainly due to the aggregation problem. This highlights the need to incorporate the firm side in asset-pricing, and confirms the relevance of the IBAPT, and the need to apply and study the IBAPT further.

### **3.2.2 Real options model**

The real options model is also a rational model, and is based on the argument that firm investment changes the risk profile of the firm, and consequently the expected share return of the firm.

Berk et al. (1999) introduced the concept of 'real options' – which they adapted from the earlier work by Myers (1977) – as an analytical tool for the relationship between firm investment and share return. This model (the real options model) assumes that firms invest optimally, and that firms and markets are rational. Based on the real options concept, the value of the firm is related to the present value of cash flows generated by assets-in-place (current assets) together with the present value of growth options (growth opportunities from future investments) (Berk et al., 1999). The present value of growth opportunities refers to the present value of options to make positive NPV investments in the future (Berk et al., 1999).

Berk et al. (1999) propose that firm investment implies an exercise of growth options. Firm investment therefore changes the relationship between assets-in-place and growth options, and this, in turn, changes the risk profile of the firm, which affects expected share returns (Berk et al., 1999). An investment with very low risk seems attractive for the firm, and investment in it leads to an increase in value. However, as a result, the average risk of the cash flows of the firm in subsequent periods is lowered, which leads to lower returns on average (Berk et al., 1999).

Firm investment entails the use of debt; hence, it follows that firm investment is associated with interest rates. The research by Berk et al. (1999) demonstrates that the present value of growth options is equivalent to options on pure discount bonds. The NPV of a project depends on the cost of capital of that project, which is itself dependent on the prevailing interest rate and risk at that time (Berk et al., 1999). Interest rates affect the expected share returns attributable to assets-in-place as well as the expected share returns attributable to growth options. With higher interest rates, future cash flows are discounted more heavily, leading to lower prices and higher expected share returns, and vice versa (Berk et al., 1999), while higher interest rates are related to lower firm investment and vice versa. Periods of high interest rates should be followed by lower risk of shares, because fewer high-risk investments would have been undertaken during these periods (Berk et al., 1999).

Berk et al. (1999), using a real options model, show that higher interest rates are related to higher expected share returns and lower firm investment, and vice versa. Berk et al. (1999) derived

Equation 3.5, where expected return is related to the book-to-market ratio and to the market value of the firm.

**Equation 3.5: Berk et al.'s (1999) expected return equation**

$$E_t[1 + R_{t+1}] = \frac{\pi D_e(r(t))}{D(r(t))} + \pi e^{\bar{C}} \left[ \frac{b(t)}{P(t)} \right] + I e^{\bar{C}} \left[ J_e^*[r(t)] - J^*[r(t)] \frac{\pi D_e(r(t))}{D(r(t))} \right] \left[ \frac{1}{P(t)} \right]$$

Where

$E_t[1 + R_{t+1}]$	=	the conditional expected return on a proportional claim on the firm
$r(t)$	=	the current interest rate
$D(r(t))$	=	the value of a perpetual, riskless bond, where the payments on this bond depreciate at a constant rate $(1 - \pi)$
$D_e(r(t))$	=	the expected value of this perpetual bond, one period hence
$\bar{C}$	=	mean of the cash flow from the project
$e^{r(t)}$	=	the gross return on the riskless asset
$b(t)$	=	book value
$J^*[r(t)]$	=	the per unit present value of all future growth options or the value of a portfolio of bond options
$J_e^*[r(t)]$	=	the expected value of a portfolio of bond options one period hence
$P(t)$	=	value of the firm at time $t$

Expected share return is a function of three terms in Equation 3.5 (Berk et al., 1999), as explained below.

- The first term  $-\pi D_e(r(t))/D(r(t))$  – reflects the effect of changing interest rates on the value of the cash flows produced by the existing assets of the firm.
- The second term  $-\pi e^{\bar{C}} \cdot b(t)/P(t)$  (where  $\pi e^{\bar{C}}$  is a positive constant) – shows that expected return is positively associated with the book-to-market ratio of the firm. The positive association of expected returns to the book-to-market ratio leads to higher average returns for firms with higher book-to-market ratios.
- The third term  $-I e^{\bar{C}} [J_e^*[r(t)] - J^*[r(t)] \cdot \pi D_e(r(t))/D(r(t))] [1/P(t)]$  – reflects the value of the growth options of the firm. Expected returns are inversely associated with market value.

Berk et al. (1999) show that firm investment can predict market value and share return, because it alters the mix of growth options to assets-in-place within the firm. These authors (Berk et al., 1999) modelled the relationship between expected returns and firm investment (assets-in-place and growth options), and derived Equation 3.5 where expected return is related to firm characteristic variables,

book-to-market ratio and to the market value of the firm (Berk et al., 1999). The book-to-market ratio and market value of the firm change with risk (on firm investment) (Berk et al., 1999). Thus, the abnormal effect of higher returns from lower investment is not 'abnormal' within the explanatory framework of this model (Berk et al., 1999). Further, investment explains both size and value-versus-growth effect. Berk et al. (1999) accordingly argue that Fama and French's (1992, 1993) empirical observations of share returns being related to size and book-to-market ratio in the three-factor model are the result of the change in the risk profile of future cash flows, stemming from the current investment decisions of the firm at the time.

Following Berk et al. (1999), Anderson and Garcia-Feijoo (2006), Trigeorgis and Lambertides (2014) and Lin et al. (2018) all considered the relationship between firm investment and share return using a heterogeneous real options model that also predicts a negative relationship between firm investment and share return. Anderson and Garcia-Feijoo (2006), Trigeorgis and Lambertides (2014) and Lin et al. (2018) further show that this relationship is associated with value-versus-growth.

Anderson and Garcia-Feijoo (2006) tested the real options model of Berk et al. (1999), and sorted portfolios according to book-to-market ratios. Anderson and Garcia-Feijoo (2006) found that there was a significant difference in investment levels between the extreme portfolios sorted according to book-to-market ratios. Anderson and Garcia-Feijoo (2006) found that growth firms have high investment levels while value firms reduce investment or disinvest. Anderson and Garcia-Feijoo's (2006) findings are consistent with those obtained by Berk et al. (1999).

Trigeorgis and Lambertides (2014) estimated growth options from market variables (firm-specific volatility, managerial flexibility and or asymmetry, organisational flexibility, financial flexibility, cash flow coverage, research and development intensity, cumulative growth, market power, fixed effects, industry effects, and interactions). These scholars show that the growth options construct, operationalised from these variables, is significantly and negatively related to share returns. Trigeorgis and Lambertides (2014) also argue that firm investment is the exercise of growth options that results in changes in both market value and share returns.

Lin et al. (2018) studied the effect of stochastic interest rates (bonds) and capital illiquidity on firm investment and firm value, using real options. The authors incorporated a term structure of interest rates into their study, and analysed the risk premium effects of the volatility in interest rates on firm investment and firm value. They (Lin et al., 2018) found that firm investment decreases with interest rates, and that the term structure of interest rates affects capital value. This is consistent with the optimal investment principles and previous real option model studies.

The real options model and IBAPT are based on the rational optimal investment principles, and both show that firm investment is related to the cost of capital. In Berk et al.'s (1999) case, the cost of capital is proxied through interest rates, and offers a risk-based explanation. With higher interest rates (higher cost of capital), firm investment is lower, and expected share returns are higher. The results are consistent showing a negative I–R relationship. Berk et al. (1999) also found that I–R explains the abnormal size and value-versus-growth factors, which correlates with the Fama and French's (1992, 1992) size and value factors empirically. Berk et al.'s (1999) concepts have been confirmed by further studies by Anderson and Garcia-Feijoo (2006), Trigeorgis and Lambertides (2014) and Lin et al. (2018). The real model results are consistent with the IBAPT, which further affirms the IBAPT. The IBAPT, however, is based on firm characteristics and is not dependent on determining risk from the market.

### **3.2.3 Macroeconomic risk model**

Cooper and Priestley (2011) found that the negative relationship between investment and share returns is related to macroeconomic risk. These authors (Cooper & Priestley, 2011) further found that the share return difference between low and high firm investment portfolios is associated to the difference in macroeconomic risk between the portfolios. Cooper and Priestley (2011) measured risk by the loadings on Chen et al.'s (1986) factors. [Chen et al. (1986) identified risk factors that are macroeconomic variables related to industrial production, real per capita consumption, yield and inflation. These authors (Chen et al., 1986) propose that macroeconomic factors, inflation, gross industrial production, long-term bonds and yields are significant for the risk of the share, and consequently affect the expected share return (Chen et al., 1986).]

Cooper and Priestley (2011) found that low-investment firms have substantially higher loadings with respect to Chen et al.'s (1986) factors than high-investment firms, especially on the growth rate of industrial production and the term spread. Cooper and Priestley (2011) found that risk falls during high-investment periods and rises in disinvestment periods. Cooper and Priestley (2011) conclude that the investment factor is related to future real growth rates of industrial production, GDP, aggregate corporate earnings and aggregate investment.

Cooper and Priestley (2011) found the negative relationship between investment and share returns to be related to macroeconomic risk (measured by Chen et al.'s [1986] risk factors), which is consistent with the risk-based explanation, and the findings are also consistent with the results from IBAPT. This further affirms IBAPT.

### 3.2.4 Empirical asset-pricing models

This section reviews the widely employed basic CAPM, the Fama and French (1992, 1993) three-factor model and the Fama and French (2015) five-factor model. It shows the development of the Fama and French (2015) five-factor model that now includes an investment factor to predict expected share return.

#### 3.2.4.1 The basic capital asset-pricing model (CAPM)

The basic CAPM – initially conceptualised by Lintner (1965), Mossin (1966), Sharpe (1964), and Treynor (1962) – is, because of its simple linear nature, one of the most widely used asset-pricing models for describing the relationship between risk and share return, despite its numerous empirical failures in various markets (Fama & French, 1992, 1993).

The basic CAPM is used to calculate the expected return of the share or portfolio (Equation 3.6) based on the risk-free rate and the risk premium. The risk premium is the systematic risk (static ‘beta’ representing the sensitivity of the share to its systematic risk) multiplied by the market premium (market premium is the expected market return minus the risk-free rate [see Lintner, 1965; Mossin, 1966; Sharpe, 1964; Treynor, 1962]).

#### Equation 3.6: The basic CAPM equation

$$E(r_j) = r_f + \beta_j (r_m - r_f)$$

Where

$E(r_j)$	=	expected return
$r_f$	=	risk-free rate
$\beta_j$	=	systematic risk (beta)
$r_m$	=	expected market return
$r_m - r_f$	=	market premium

Treynor (1962) based his model on an idealised frictionless market, to model the behaviour of intelligent investors, using their own capital towards risk, where investors would need a premium to hold an asset that is riskier than cash. Under equilibrium and rational assumptions based on diversification, the additional expected share return is solely based on the pure interest rate (price of time or waiting) and the price of risk (Sharpe, 1964).

Sharpe (1964) introduced the construct of “systematic risk” (Sharpe, 1964, p.436), which Sharpe (1964) define as the component of the asset’s total risk, based on a portfolio of selected assets,

correlated with the variation in return, based on common dependence on market economics. The assumption is that diversification through arbitrage enables the investor to escape risks but systematic risk (as a result of market economics) remains. Prices will adjust so that this linear relationship can hold (Sharpe, 1964). Assets that are unaffected by changes in market economics (no systematic risk) will return the pure interest rate (risk-free rate), while those that are affected by such changes will return higher rates based on this systematic risk (Sharpe, 1964).

Lintner's (1965) capital budgeting decision in terms of the minimum expected return is based on the risk-free rate of return, the market price of risk, the variance in the project's own return, the project's aggregate return co-variance with other assets of the firm, and co-variance with other projects in the capital budget of the firm (see Lintner, 1965). Lintner (1965) shows that, in terms of any arbitrarily selected share portfolio, the investor's net expected rate of return on their investment is linearly related to the risk of return on the investment, measured by the variances of returns.

Mossin (1966) further developed the concept that returns are the sum of the risk-free rate plus the risk premium, based on all investors acting rationally, creating market equilibrium.

There is wide empirical evidence that the basic CAPM does not effectively model expected share returns (Berk et al., 1999; Cochrane, 1991, 1996; Fama & French, 1992, 1993, 2004, 2008; Li et al., 2009; Liu et al., 2009; Ward & Muller, 2012), especially when comparing firms with different characteristics such as different investment levels, book-to-market ratios, market value, and equity issuance. These conditions are referred to as 'anomalous' because they do not fit the basic CAPM. It is predominantly on the basis of this argument that behavioural theorists (such as Alti & Tetlock, 2014; Cooper et al., 2008; Lam & Wei, 2011; Li & Sullivan, 2011; Li & Zhang, 2010; Lipson et al., 2011; Mortal & Schill, 2015; Song, 2016; Stambaugh & Yuan, 2017) argue that markets are inefficient and therefore rational assumptions cannot hold.

Specifically, the basic CAPM does not account for firms with lower investment showing higher share returns and vice versa (Berk et al., 1999; Cochrane, 1991, 1996; Fama & French, 1992, 1993, 2004, 2008; Li et al., 2009; Liu et al., 2009; Ward & Muller, 2012), which was one of the specific concerns of this research. IBAPT addresses this concern (Zhang, 2017).

#### **3.2.4.2 Fama and French's (1992, 1993) three-factor empirical model**

Fama and French (1992, 1993) studied the empirical inconsistencies of the basic CAPM. Based on US data for the period 1969–1989, it was found that firms with different book-to-market ratios, leverage, market value and earnings-to-price ratios behaved differently to the basic CAPM. Based again in US data, Fama and French (1992, 1993) empirically found that the simple relationship between systematic risk and average share return was very weak for the period 1941 to 1990.

They further conclude that size and book-to-market ratio seem to absorb the effect of leverage and earnings-to-price ratio (Fama & French, 1992, 1993). The authors propose that risk related to shares is multidimensional, and that size and book-to-market ratio proxy as other dimensions of risk, and further suggest that the book-to-market ratio could be related to the distress factor of Chan and Chen (1991). Chan and Chen (1991) argue that small firms could be more risky than large firms, as small firms could be marginal and highly sensitive to changes in the economy, with lower production efficiencies, higher financial leverage, and more significant cash flow problems than large firms.

Fama and French (1992, 1993) empirically found that share return could be related to size premium (SMB or 'small minus big') and value premium (HML or 'high minus low') risk factors. The size premium is the market capitalisation risk factor and measures the additional return from relatively small market capitalisation shares. The value premium measures the additional return from shares with high book-to-market ratios. The Fama and French (1992, 1993) three-factor model augments the basic CAPM by incorporating the firm characteristics of size and value as risk factors in addition to beta (Fama & French, 1992). The Fama and French (1992, 1993) model thus offers improved empirical consistency. Size and value risk factors combined with beta explain the cross-sectional variation in average share returns more effectively than beta alone (Anderson & Garcia-Feijóo, 2006; Berk et al., 1999; Xing, 2008).

**Equation 3.7: Fama and French (1992, 1993) three-factor equation**

$$E(r_j) = r_f + \beta_j (r_m - r_f) + s_j \text{SMB} + h_j \text{HML}$$

Where

$E(r_j)$	=	expected return
$r_f$	=	risk-free rate
$\beta_j$	=	beta
$r_m$	=	expected market return
$r_m - r_f$	=	market premium
SMB	=	size premium ('SMB' market capitalisation risk factor)
HML	=	value premium ('HML' value premium risk factor)

SMB measures the additional return from relatively small market capitalisation shares

HML measures the additional return from shares with high book-to-market ratios.

The Fama and French (1992, 1993) three-factor model sought to address the issues with the basic CAPM, with limited success. This has resulted in the Fama and French (2015) five-factor model recently formulated to address these concerns.



### 3.2.4.3 *Fama and French's (2015) five-factor empirical model*

Fama and French (2015) subsequently added the robust minus weak profitability (RMW) and conservative minus aggressive investment (CMA) factors to the three-factor model of Fama and French (1992, 1993) to formulate the five-factor model.

#### **Equation 3.8: Fama and French (2015) five-factor equation**

$$E(r_j) = r_f + \beta_j (r_m - r_f) + s_j \text{SMB} + h_j \text{HML} + r_j \text{RMW} + c_j \text{CMA}$$

Where

$E(r_j)$  = expected return

$r_f$  = risk-free rate

$\beta_j$  = beta

$r_m$  = expected market return

$r_m - r_f$  = market premium

SMB = size premium (market capitalisation risk factor)

HML = value premium (value premium risk factor)

RMW = robust minus weak profitability factor

CMA = conservative minus aggressive investment factor

SMB measures the additional return from relatively small market capitalisation shares.

HML measure the additional return from shares with high book-to-market ratios.

CMA captures the effect of lower investment firms with higher share returns. According to Fama and French (2016), anomalies left unexplained by the Fama and French three-factor model reduce when the Fama and French five-factor model is employed. According to Fama and French (2017), share returns increase with book-to-market ratio and profitability, and share returns are negatively related to investment the US. Fama and French (2017) argue that the Fama and French (2015) five-factor model, which adds profitability and investment factors, largely absorbs anomalous patterns in share returns.

There is wide empirical evidence that the basic CAPM does not effectively model share returns. This was one of the specific concerns of this research, which is addressed by the IBAPT, and also in parallel addressed by the Fama and French (1992, 1993) three-factor model and the Fama and French (2015) five-factor model. Previous studies in the risk-based literature (see section 3.2.2) have found that the investment factor is correlated to the SML and HML factors of Fama and French (1992, 1993). Hou et al. (2015) further note that the investment factor incorporates the value effect, and that the size factor may not be relevant with the IBAPT. The Fama and French (2015) five-factor model

now also includes the investment and profitability factors. There is a convergence of and improved success between the parallel literatures of these empirical models and the nascent IBAPT (which is based on fundamental investment principles) in including the firm investment factor and the expected profitability factor to explain expected share returns.

### **3.3 Contrasting behavioural theories**

This section discusses the contrasting behavioural explanations for the negative relationship between firm investment and share return. Behavioural theorists argue that biased behaviours of overinvestment by firms and mispricing by investors result in an anomalous negative I–R relationship. This anomaly cannot be corrected, as explained by the limits of arbitrage theory of Shleifer and Vishny (1997). This contrasting behavioural-based explanation to the rational-based explanation is discussed further below. Testing the behavioural explanation was not part of the scope of the current research.

#### **3.3.1 *Limits to arbitrage***

Based on Shleifer and Vishny's (1997) limits to arbitrage theory, the proponents of behavioural explanations (such as Alti & Tetlock, 2014; Cooper et al., 2008; Lam & Wei, 2011; Li & Sullivan, 2011; Li & Zhang, 2010; Lipson et al., 2011; Mortal & Schill, 2015; Song, 2016; Stambaugh & Yuan, 2017) argue that the rational-based explanation for the negative I–R relationship cannot hold, and instead the negative relationship is due to an overinvestment and mispricing explanation.

Shleifer and Vishny (1997, p.35) refer to Sharpe and Alexander's (1990) definition of arbitrage as the "simultaneous purchase and sale of the same, or essentially similar, security in two different markets for advantageously different prices". The rational assumption is based on the principle that arbitrage would result in prices being close to fundamental values, consistent with Fama's (1970) efficient market hypothesis (EMH). According to the EMH, an efficient market is one in which prices (or share returns) "fully reflect" (Fama, 1970, p.383) all available information (Fama, 1970). The role of arbitrage is to align prices with fundamental values; however, this is based on the assumption that arbitrage entails no risk and requires no capital (Shleifer & Vishny, 1997). Shleifer and Vishny (1997) propose that arbitrage is risky and requires significant capital, and therefore effective arbitrage does not take place to correct pricing anomalies.

Shleifer and Vishny (1997) argue that, in order for the EMH to work, the market should comprise a very large number of very small arbitrageurs, each taking an infinitesimal position against mispricing. These very small arbitrageurs would take very small positions, capital constraints would not be

binding, and they would be risk-neutral towards each transaction. The collective actions of the arbitrageurs would drive prices toward fundamental values. Shleifer and Vishny (1997), however argue that these many small traders do not have the capital, knowledge or information to engage in arbitrage. Arbitrage is instead conducted by relatively few professional, highly specialised, arbitrageurs operating as agents for providers of capital (Shleifer & Vishny, 1997). The providers of capital are wealthy individuals, banks, and other investors with limited knowledge of the markets. Volatility exposes the arbitrageurs to the risk of losses that they may want to avoid because they face financial constraints from their providers of capital and will avoid risk for these providers (Shleifer & Vishny, 1997). Arbitrage positions may offer arbitrageurs attractive returns; however, these positions also expose arbitrageurs to risk of losses, which they would instead want to avoid. Shleifer and Vishny (1997) model the behaviour of different types of institutional investors and conclude that high-volatility and risk deter arbitrage.

Shleifer and Vishny (1997) conclude that due to limits to arbitrage, anomalies cannot be explained rationally, instead one should turn to examining the pattern of investor sentiment (or bias behaviours) responsible for the anomaly and the costs of arbitrage preventing the anomaly from being eliminated. According to the behaviour proponents, the bias behaviours of overinvestment and mispricing (discussed in sections 3.3.2 and 3.3.3) result in the anomaly which cannot be corrected, explained by Shleifer and Vishny's (1997) limits to arbitrage theory.

The current research was set in a context that could be described by the behavioural proponents as a context of high limits to arbitrage (discussed in Chapter 2). Zhang (2017) and the rational proponents discussed in sections 3.1 and 3.2 argue that this theory is not relevant in explaining the I–R relationship.

### **3.3.2 *Overinvestment***

'Overinvestment' refers to the biased behaviour of managers of firms. Overinvestment is related to the idea that managers invest more than they ought to (Kruger, Landier, & Thesmar, 2015), because managers either overestimate the projected cash flows or underestimate the cost of capital of projects, resulting in an overinvestment problem in terms of the DCF equation (Equation 3.1) (Kruger et al., 2015). Since managers have more knowledge about the firm than investors, and because managers act as agents (information asymmetry and agency conflict theory) (La Porta, Lopez-de-Silanes, & Shleifer, 2006), they also control the investment policies and financing decisions of the firm, which may not ultimately benefit shareholders (Bessler et al., 2011).

Overinvestment may be linked to manager hubris (Cooper et al., 2008; Titman et al., 2004). Titman et al. (2004), using US data from between 1973 and 1996, argue that firms with greater investment

discretion show a negative I–R relationship, while firms with less investment discretion, show a positive I–R relationship. Titman et al. (2004) used high cash flows, low debt ratios and (less) prevalence of hostile takeovers as an indication of high management discretion. They attribute the negative I–R relationship to managers' inefficient overinvestment decisions and "empire building" (Titman et al., 2004, p.678).

In their cross-sectional study, Cooper et al. (2008) also found that firm investment is a significant predictor of expected share return in the United States, and that this effect is a pervasive phenomenon in the United States. Cooper et al. (2008) argue that in their study, the I–R relationship was less negative with increased rather than reduced corporate oversight (similar to findings by Titman et al., 2004). They argue that the I–R relationship is related to overinvestment and investor mispricing (discussed below in section 3.3.3) where investors overreact to past firm growth rates, earning announcements, and corporate oversight. Cooper et al. (2008) propose their results as inconsistent with the results obtained by Berk et al. (1999) and the Fama and French (1992, 1993) three-factor model.

The overinvestment hypothesis was not tested in this research. However, the study related the observations by the behaviour proponents to the IBAPT. Instead, the current study followed the scientific research philosophy and related the profitability effect to the investment category in Hou et al. (2015) q-factor model, discussed in section 3.1.

### **3.3.3 *Mispricing***

Semnarayan et al. (2018) discuss the scholarship around mispricing in their study of investment returns on the JSE. What follows draws on that article, the co-writing of which contributed to the development of this thesis. 'Mispricing' refers to the biased behaviour of investors on the stock market. The biased behaviour of investors relates to Lakonishok et al. (1994) who suggest a systematic pattern of judgement errors on the part of investors in predicting returns, because they place excessive weight on the recent performance history of the firm. The example proposed is that investors consistently overestimate the future growth rates of glamour stocks relative to value stocks.

Li and Zhang (2010), Lam and Wei (2011), Li and Sullivan (2011), Lipson et al. (2011), Alti and Tetlock (2014), Mortal and Schill (2015), Song (2016), as well as Stambaugh and Yuan (2017) employ Shleifer and Vishny's (1997) limits to arbitrage theory and Lakonishok et al.'s (1994) proposition in discussing the phenomenon of investor mis-reactions to the investment decisions of a firm and mispricing 'relative to risk and return' that cannot be arbitrated away. Investor biases cause returns to diverge from their true values (Alti & Tetlock, 2014; Cooper et al., 2008) and arbitrage

constrained as Shleifer and Vishny (1997) assert cannot narrow these gaps. More precarious conditions – such as those of the JSE – raise arbitrage costs intensifying the ineffectiveness of arbitrageurs' attempts and further distancing prices from their fundamental values. According to the behaviour proponents, this could explain the negative relationship between firm investment and share return. The behaviourally-based explanation thus suggests that the kind of market volatility experienced in a developing economy such as South Africa would give rise to a negative I–R relationship.

Behaviour proponents tested the competing risk-based explanation, by investigating whether firms with higher financing constraints (proxy for higher investment frictions or higher discount rates) show a stronger negative I–R relationship than firms with lower financing constraints. They did not find support for this hypothesis. The premise here was that the investment premium should be stronger when investment entails more 'friction' (Lam & Wei, 2011; Li & Zhang, 2010), based on the risk-based explanation. They use financing constraints as an indicator of investment frictions, suggesting that higher financing constraints create conditions for a higher discount rate (resulting in lower investment based on the risk-based explanation). Thus, the inference is that the negative I–R relationship should be steeper in firms with high "investment frictions" (Li & Zhang, 2010, p.298) than in firms with low frictions.

Li and Zhang (2010) use three financing constraint proxies: asset size, payout ratio, and bond ratings. Their assumption is that firms with small assets, low payout ratios, and unrated public debt are financially more constrained than firms with substantial assets, high payout ratios, and rated public debt. Lam and Wei (2011) employ four proxies of financial constraints representing investment frictions: firm age; asset size; payout ratio; and credit rating. Li and Zhang (2010) and Lam and Wei (2011) found weak evidence for a stronger negative I–R relationship in financially more constrained firms than financially less constrained firms.

Behaviour proponents tested whether limits to arbitrage measures (high-volatility and low-turnover) correlated with the negative I–R relationship. They found support for this hypothesis. Li and Zhang (2010) found that their proxies for investment frictions (financing constraint proxies: asset size, payout ratio, and bond ratings) correlated with those for limits to arbitrage measures (IVOL and trading volume). Using IVOL as a proxy for arbitrage costs, Li and Sullivan (2011) argue that the negative I–R effect is due to arbitrage costs, because in their sample of higher arbitrage barriers, the effect was stronger than in their sample of lower arbitrage barriers. This result is contrary to that obtained by risk proponents such as Titman et al. (2013). Lipson et al. (2011) take IVOL to be an indication of arbitrage costs, defining IVOL as "the standard deviation of the residuals from a

regression of daily returns on an equal-weighted market index over a minimum of 100 days starting from July 1 through June 30 of the present year” (Lipson et al., 2011, p.1665).

Lipson et al. (2011) argue that the negative I–R relationship is linked to firm IVOL, that the effect is concentrated around earnings announcements, and that analyst forecasts are systematically higher than realised earnings for faster-growing firms. Lipson et al. (2011) found there is no negative I–R relationship for firms with low IVOL, concluding that the negative I–R relationship is consistent with the mispricing-based explanation where limits to arbitrage allow the anomaly to persist. Lam and Wei (2011) conducted tests using ten proxies of limits to arbitrage:

- idiosyncratic volatility (IVOL);
- analyst coverage;
- analyst forecast dispersion;
- cash flow volatility;
- number of institutional shareholders;
- share price;
- bid-ask spread;
- institutional ownership;
- absolute return-to-volume; and
- dollar trading volume.

Lam and Wei (2011) show that the proxies for limits to arbitrage are highly correlated with those for investment frictions. Song (2016) studied the relationship between firms’ investment and idiosyncratic share return volatility. In their cross-sectional study, they found firms’ idiosyncratic return volatility to be V-shaped (non-linear) with respect to firm volatility. Song (2016) found that volatility is higher for firms with extreme (either high or low) firm investment than for firms with moderate firm investment.

Alti and Tetlock (2014) reject the hypothesis that investors do not exhibit biases and managers invest efficiently. They assert that firms make investment decisions and investors make pricing decisions based on their biases of the productivity of the firm (Alti & Tetlock, 2014). Alti and Tetlock (2014) further show how the choices affected by these biases generate endogenous relationships in and among firm investment, profitability, firm valuation and share returns. Overconfident investors believe the precision of the “soft signal” (Alti & Tetlock, 2014, p.327) – defined by these authors as the subjective interpretation of news events other than cash flow realisations – to be more significant than they actually are. Investors who extrapolate believe the persistence of firm productivity to be higher than it actually is. Investor bias behaviour (Alti & Tetlock, 2014) exacerbates the negative I–R

relationship and value anomaly, as managers overinvest to maximise the current asset prices of the firm whenever investor optimism towards the firm increases irrationally. Biased investors are optimistic on growth firms which they believe to be good future growth opportunities. Such investors are pessimistic regarding value firms, which they perceive as riskier than growth firms. This behaviour results in share returns being higher for value firms than for growth firms, and exacerbates the anomaly (Alti & Tetlock, 2014).

Stambaugh and Yuan (2017) compared the q-factor model, the Fama and French three-factor model, the Fama and French five-factor model and their own four-factor mispricing model. The authors developed their own four-factor mispricing model, based on anomalies that they selected. Their mispricing model includes the market and size factor, and the other two factors constructed by clustering a number of anomalies found in the market together. Stambaugh and Yuan (2017) argue for their four-factor mispricing model and suggest that it is better to aggregate a cluster than to use individual firm factors. Zhang (2017) concludes that the mispricing factors chosen by Stambaugh and Yuan (2017) are correlated to the q-factors of expected profitability and firm investment.

The above behaviour proponents oppose the risk-based explanation. They propose that manager hubris and overinvestment, as well as investor biases result in the negative I–R anomaly, and that limits to arbitrage prevent arbitrageurs from eliminating mis-reactions and mispricing. The mispricing hypothesis was not tested in the current research. However, the study related the observations by the behaviour proponents to IBAPT. The researcher followed the IBAPT, where the abnormal effects were related to the investment factor and expected profitability factor as per the investment CAPM and q-factor model discussed in section 3.1.

### **3.4 Summary of the literature**

A negative relationship between firm investment and subsequent share return was found in the US efficient markets. This is contrary to the view that firms with higher investment rates should have higher subsequent shareholder returns than firms with lower rates. There are three prominent areas of knowledge related to this – IBAPT, risk and behaviour. The current study was anchored on the nascent IBAPT that relates share returns directly to firm characteristics.

According to the IBAPT, firm investment can be directly related to shareholder returns (Cochrane, 1991). Returns on investment at firm level are equivalent to share returns at market level (Cochrane, 1991). In terms of the optimal investment principle, to maximise the value of the firm, firms invest to the level of the cost of capital (which is equivalent to the share return). The investment CAPM is a new class of asset-pricing that relates firm characteristics to share return. In terms of the investment

CAPM (Hou et al., 2015; Liu et al., 2009; Zhang, 2017), share return is related to firm investment and expected profitability. Empirically, Hou et al. (2015) show that the investment premium is related to the abnormal observations in the market – value-versus-growth, and other investment effects (which could include profitability, debt-to-equity, and equity issuance effects).

Other rational scientists (see Anderson & Garcia-Feijoo, 2006; Berk et al., 1999; Cooper & Priestley, 2011; Fama & French, 1992, 1993, 2015; Lin et al., 2018; Trigeorgis & Lambertides, 2014) explain the I–R relationship to risk. Using real options models or macroeconomic risk models, these authors found that the negative I–R relationship is related to the changing risk profile of the share. The risk-based explanation (section 3.2) asks which risks explain asset-pricing anomalies. The risk-explanation is mainly based on the consumption perspective, which asserts that demand-side risks are sufficient to predict expected share returns, and after these risks are controlled for, firm characteristics should not matter. The problem with this is aggregation as explained in section 3.2.1. The investment CAPM broadens the EMH beyond the risk body of knowledge.

The basic CAPM, which includes the market systematic risk ( $\beta$ ), is a special case of a consumption-based asset-pricing model. Fama and French (1992, 1993) added size and value factors to the basic CAPM to improve its empirical success. In parallel to the IBAPT studies (Hou et al., 2015), Fama and French (2015) added expected profitability and firm investment as factors to the Fama and French (2015) five-factor model to address inadequacies with the Fama and French (1992, 1993) three-factor model.

In contrast, the behavioural proponents do not believe that the market is rational, and argue that the basic premise of the EMH used by rational scientists cannot hold due to the costs of arbitrage. Instead, the behavioural proponents argue that the negative I–R effect, and the other abnormal effects observed are due to psychological biases from the firm and the market, which cannot be arbitrated away. Zhang (2017) maintains that this is unfortunate, and argues against this, supported by the body of evidence for the rational approach, and further claims that this is no reason for firms and managers to be biased with respect to the phenomena studied. Zhang (2017), however, inappropriately generalises developing markets, as inefficient in which the negative I–R relationship may not hold, according to the researcher of this current study. Although small and volatile, the South African financial market is liberal, and open with one of the strongest financial systems internationally (The World Bank, 2017). This study extended IBAPT to this market.

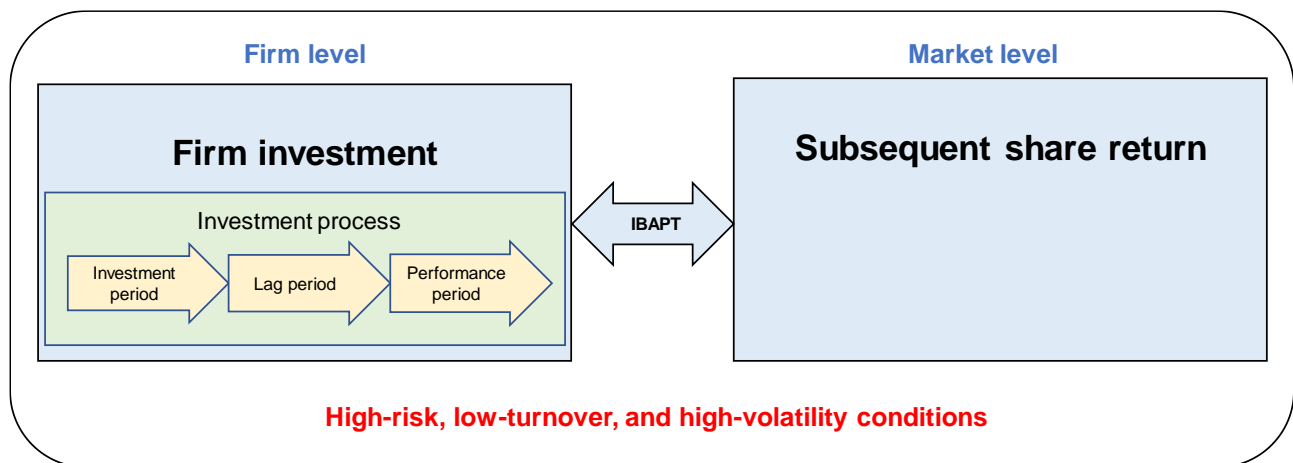
According to Zhang (2015, p.593), the investment CAPM “predicts that characteristics are sufficient statistics for expected returns, and after characteristics are controlled for, risks should not matter”. The study on which this thesis reports, was anchored in and adopted the nascent IBAPT that relates



share return to firm characteristics. Zhang (2017) explains why this theory is superior to the risk-based or behaviour approaches. The study further extended this theory by expanding firm characteristics (in terms of investment process variables – investment period, lag period and performance period).

### 3.5 Conceptual model and hypotheses

The conceptual model (see Figure 3.1) for this research was based on the IBAPT, where share returns are modelled from the perspective of firm investment. The IBAPT shows that firm investment and share returns are aligned. Cost of capital (equivalently share returns) drives investment by firms. The context of the study was high-risk, low-turnover, and high-volatility conditions (see Chapter 2), which is distinctively different from contexts examined in previous studies, and which would have been classified as a context with high arbitrage costs in previous literature. In the current study, the concept of firm investment was expanded to include the investment process variables of investment period, lag period and performance period.



**Figure 3.1: Conceptual model**

**Source: Researcher's model**

#### 3.5.1 I-R relationship, investment and lag periods

Based on the investment process of firms, the relationship between firm investment and subsequent share return could be dependent on the investment process variables of investment period and lag period, according to the researcher. The investment process variables are explained in section 4.7. Hypothesis 1 was formulated by incorporating these variables, the context of study, and based on the IBAPT that explains the direct relationship between firm investment and share return (see sections 3.1).

Hypothesis 1: The relationship between firm investment and subsequent share return is dependent on the investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

### **3.5.2 Significant negative I–R relationship**

Hypothesis 2 was based on the IBAPT and on previous rational studies (by rational proponents such as Anderson & Garcia-Feijoo, 2006; Berk et al., 1999; Cochrane, 1991, 1996; Cooper & Priestley, 2016; Cordis & Kirby, 2017; George et al., 2018; Hou et al., 2015; Lin et al., 2018; Liu et al., 2009; Trigeorgis & Lambertides, 2014; Zhang, 2017) which found a significant negative relationship between firm investment (I) and subsequent share return (R).

Based on the investment CAPM, share return is directly related to firm investment, negatively (see section 3.1), initially conceptualised by Cochrane (1991). Cochrane (1991) derives the investment return equation (Equation 3.2), where share return equals the investment return of the production process, made possible through arbitrage. Liu et al. (2009) demonstrate that this relationship holds even in the presence of debt and taxes.

Cooper and Priestley (2016) applied the investment CAPM to private firms and found that the investment factor directly relates to share return, similar to findings for listed firms by Liu et al. (2009) (see section 3.1). Cordis and Kirby (2017) applied the investment CAPM to the NYSE, AMEX and NASDAQ firms, on data from July 1963 to December 2012, cross-sectionally, and found that the relationship between share return and firm investment was quadratic. The I–R relationship is negative at low investment levels, close to zero at intermediate investment levels and negative at high investment levels. They interpret this as consistent with the IBAPT (see section 3.1). George et al. (2018) also found the q-factor model helps to explain other anomalies observed in the market, specifically the price-to-high anomaly is related to I–R, which they interpret as consistent with the IBAPT.

Berk et al. (1999) using a real options model, show that higher interest rates are related to higher expected share returns and lower firm investment, and vice versa (section 3.3.). Following Berk et al. (1999), Anderson and Garcia-Feijoo (2006), Trigeorgis and Lambertides (2014) and Lin et al. (2018) all consider the relationship between firm investment and share return using a heterogeneous real options model that also predicts a negative relationship between firm investment and share return (see section 3.3). Cooper and Priestley (2011) found that the negative relationship between investment and share returns is related to macroeconomic risk (measured as Chen et al.'s [1986] risk factors), which is consistent with the risk-based explanation.

There is convergence and success between the parallel literatures of empirical models and the nascent theory of IBAPT (which is based on finance fundamentals) by including the firm investment factor (specifically Fama and French [2015] five-factor Equation 3.8) to explain expected share returns. Fama and French's (2015) five-factor equation includes the CMA, which captures the effect of lower investment firms with higher share returns.

Based on this literature and incorporating the investment process variables (explained in section 4.7), and context (explained in Chapter 2), hypothesis 2 was formulated.

Hypothesis 2: There is a significant negative relationship between firm investment and subsequent share return, which is dependent on the investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

### **3.5.3 *I-R association with abnormal effects***

The I–R relationship is associated with abnormal effects (book-to-market effect, size effect, equity issuance effect, debt-to-market equity effect, and profitability effect) observed in the market, explained by the IBAPT literature and models described in this section.

#### **3.5.3.1 *I-R association with book-to-market***

Hypothesis 3.1 examines the power of the firm investment factor in empirically explaining the value-versus-growth effect in the market. Hou et al. (2015) studied 80 anomalies in the US market and developed the q-factor model. They found that firm investment explains the anomalies related to value and growth (Hou et al., 2015, p.664). Based on the q-factor asset-pricing model (Hou et al., 2015, Equation 3.3), the firm investment factor captures anomalies related to value-versus-growth and other investment effects observed in the market. Value-versus-growth is therefore not specifically included as a separate factor in their asset-pricing model, contrary to Fama and French (2015).

Berk et al. (1999) derived Equation 3.5, where expected return is related to the book-to-market ratio of the firm (Berk et al, 1999, p.1554). Anderson and Garcia-Feijoo (2006) tested the real options model of Berk et al. (1999), and sorted portfolios according to book-to-market ratios. Anderson and Garcia-Feijoo (2006) found that there is a significant difference in investment levels between the extreme portfolios sorted according to book-to-market ratios. Firm with high investment growth earn significantly lower subsequent share returns than firms with low investment growth.

Fama and French's (2015) five-factor equation includes HML value premium as the measure of the additional return from shares with high book-to-market ratios.

Based on this literature and incorporating the investment process variables (explained in section 4.7), hypothesis 3.1 was formulated.

Hypothesis 3.1: The I–R relationship is associated with the book-to-market abnormal effect, which is dependent on investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

### **3.5.3.2 I–R association with size**

Size is not included as a factor in the investment CAPM (see section 3.1). Hou et al. (2015) include size in their q-factor model (Equation 3.3), which is based on the IBAPT; however they also note that size may not be necessary in the model (see section 3.1).

Berk et al. (1999) derived Equation 3.5, where expected return is related to the market value of the firm. (Berk et al, 1999, p.1554) (see section 3.2.2). Anderson and Garcia-Feijoo (2006) also suggest that I–R is related to size (see section 3.2.2). Fama and French's (2015) five-factor equation includes SMB size premium as the measure of the additional return from relatively small market capitalisation shares (section 3.2.4).

Based on this literature and incorporating the investment process variables (explained in section 4.7), hypothesis 4 was formulated.

Hypothesis 3.2: The I–R relationship is associated with the size abnormal effect, which is dependent on investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

### **3.5.3.3 I–R association with equity issuance**

The investment factor captures anomalies in the investment categories (Hou et al., 2015) (see section 3.1). The investment category would include equity issuance, debt-to-market equity and profitability of the firm.

The equity issuance effect (also sometimes termed the “new issues puzzle” [Lyandres et al., 2008, p.2826]) refers to lower subsequent returns that have been observed in the market for firms that have higher equity issuance. This could be related to investment. Based on the balance sheet constraint of firms, funds that a firm uses must equal its sources of funds; therefore, issuers must

invest more and earn lower average returns than non-issuers (Lyandres et al., 2008). Firm investment is significantly correlated to equity issuance and issuers have lower costs of capital than non-issuers (Li et al., 2009; Lyandres et al., 2008) (see section 3.1).

Cooper et al. (2008) observe that firm investment events, such as acquisitions, equity issuance and increased borrowings, tend to be followed by periods of abnormally low share returns, and firm divestment events (such as share repurchases, dividend payouts and debt repayments) tend to be followed by periods of abnormally high share returns (Cooper et al., 2008).

Based on this literature and incorporating the investment process variables (explained in section 4.7), hypothesis 3.3 was formulated.

Hypothesis 3.3: The I–R relationship is associated with the equity issuance effect, which is dependent on investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

#### **3.5.3.4 I–R association with debt-to-market equity**

Debt can be used to finance investment. The risk-shifting view (Cao et al., 2008) means that managers of levered firms (those acting on behalf of equity holders) have incentives to exercise growth options (make capital investments), where risk is shifted to debt-holders, while equity holders benefit from an increase in their equity value and a decrease in the market risk of their equity (Cao et al., 2008).

Based on this literature and incorporating the investment process variables (explained in section 4.7), hypothesis 3.4 was formulated.

Hypothesis 3.4: The I–R relationship is associated with the debt-to-market equity effect, which is dependent on investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

#### **3.5.3.5 I–R association with profitability**

Investment is associated with the profitability of the firm, because firms that are more profitable tend to invest more than firms that are less profitable (Hou et al., 2015). Higher firm investment is related to higher cash flows, which is related to lower subsequent share returns, as also argued by Titman et al. (2004).

Based on this literature and incorporating the investment process variables (explained in section 4.7), hypothesis 3.5 was formulated.

Hypothesis 3.5: The I–R relationship is associated with the profitability effect, which is dependent on investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

## **Chapter 4: Research design and methodology**

As part of the research process, an article was published which helped refine this work, as discussed (see section 4.1). The research philosophy (see section 4.2) pursued was that of the neoclassical and scientific view, in contrast to the behaviouralist view. In contrast, the behaviour proponents would have described the South African market as inefficient and would describe the negative I–R relationship as an ‘anomaly’ that cannot be explained rationally.

The buy-and-hold research strategy and software developed for the study are described (see section 4.3). A snapshot of The JSE data is described with respect to the time period, types of firms, size of firms, number of firms and industries (see sections 4.4, 4.5 and 4.6). The definition of the variables used to operationalise the constructs of the study is presented in section 4.8. The research procedures undertaken and the statistical methods used to test each of the hypotheses are described in section 4.9. Bootstrap was accomplished using random profiles from the actual population, which improved the determination of statistical significance of the negative I–R relationship.

Quality assurance measures built into the software procedures are discussed (see section 4.10 and 4.11). The limitations of the study are listed (see section 4.12), which offers opportunities for further study and research (discussed later in Chapter 7). Secondary publically available data was used for the study, ensuring the right to privacy, confidentiality and anonymity of the study, discussed in this chapter.

### **4.1 Research process**

As part of the PhD study process, initial findings of my study were presented at the Southern African Finance Conference in January 2018; and an article (Semnarayan et al., 2018) was written and published, with my supervisors as co-authors, in August 2018. This was to obtain independent external review and approval of the relevance and novelty of the study from finance academics and practitioners. It was important to go through this process, as the writing, external review and feedback helped refine my work. My role as primary author and student in these processes was that of researching, putting the article together, and presenting the article. The main role of the co-authors was to support the modelling of the data using the style engine, and to provide oversight. The researcher drew from and enhanced on this work, further incorporating the most recent literature and data up to March 2019 in this thesis. The article (Semnarayan et al., 2018) used the linear measure of firm investment. This thesis primarily used the LOGEST function, which was a new and reliable approach to measure firm investment. The linear measure uses just two data points over the

period – the start and end points. The LOGEST measure fits a line to all the points over the period and uses the slope of the line. For example, if the investment period is 10 years, the linear measure would determine the linear change in net asset growth between the starting period and the end period, using just these two points. The LOGEST measure fits a line to all 10 years off the data, and uses the slope of this line.

## **4.2 Research philosophy and approach**

The purpose of this research was to examine, using time-series, the relationship between firm investment variables and subsequent share returns, in a developing market context. It adopted a positivist research paradigm: one where the contribution to knowledge is based on observation and on testing and developing theory (Bacharach, 1989; Bryman, 1984; Hill, 1984).

The study further adopted an objective ontology (Bryman, 1984; Hill, 1984), in which the firms and financial markets analysed were external to the researcher. In epistemological terms, it is the researcher's view that the natural science model constitutes acceptable knowledge (Bryman, 1984; Hill, 1984). Hypotheses based on the IBAPT were tested via processes of determination, reductionism and empirical measurement and are reported here. The concepts of firm investment and share return were reduced to discrete operational variables. These concepts were further related to observable firm and market characteristic variables. The researcher found generalised relationships by statistically analysing the observed historical data of firms.

The current research was based on secondary firm and market data, the researcher was independent of the data, and the research axiology was value-free. A deductive research approach and quantitative methodology (Bacharach, 1989; Bryman, 1984; Hill 1984) were followed in this study. A conceptual model and hypotheses were developed based on existing literature and theory and a research strategy designed to test these hypotheses (see section 3.5). Concepts were operationalised (see section 4.8) and a buy-and-hold research strategy (see section 4.3) was used.

According to Zhang (2017), finance scholarship is driven by an important debate: neo-classicists seek to explain 'anomalies' using microeconomic rational theory, while behaviouralists view anomalies as a rejection of the EMH and of neoclassical economics. Behaviouralists such as Shleifer and Vishny (1997) reject EMH because of the limitations of arbitrage in any market. Practitioners often embrace this behavioural view and dismiss neo-classicists as "theoretical purists who have lost touch with the real world" (Zhang, 2017, p.582). However, Zhang (2017) views anomalies not as an indictment of the EMH, but of empirical difficulties of consumption-based asset-pricing which is conceptually incomplete. The IBAPT is a rational theory and offers a new perspective, incorporating



constructs from both the firm and market sides. This work thus sustains the study of neoclassical theory in a market ostensibly characterised by high arbitrage costs and deemed inefficient.

### **4.3 Buy-and-hold portfolio research strategy**

The buy-and-hold portfolio research strategy (Rekenthaler, Gambera, & Charlson, 2006) was employed in this study. Buy-and-hold involves buying the share at a specific time, holding it, and then selling it after a period (Rekenthaler et al., 2006). The buy-and-hold portfolio research strategy is also referred to as the “fundamental or portfolio-based style analysis” (Rekenthaler et al., 2006, p.25). These authors (Rekenthaler et al., 2006) further describe the buy-and-hold portfolio research strategy as a bottom-up fundamental approach, where the portfolio is classified by an investment style, and the characteristics of the portfolio are derived from the characteristics of the shares that the portfolio contains.

The investment style is the principle variable by which a portfolio is classified (Rekenthaler et al., 2006). When compared to alternative investment style research strategies, such as returns-based style analysis (where a style is regressed against an index of styles) (see Rekenthaler et al., 2006), the buy-and-hold strategy is preferred due to its accuracy, consistency and flexibility; however Rekenthaler et al. (2006) suggest the cost of data is high. Portfolios are formed based on the ranking of the selected style variable(s), and the comparative performance of portfolios is analysed. Portfolios are used to reduce the noise in the data and a time-series approach is used to compound the effect of the style variable selected (Muller & Ward, 2013). ‘Noise’ here refers to interference from variables outside the system being studied, and an effective method for filtering data is required to study time-series financial data (Hassani, 2010).

A ‘style engine’ constructed using the Excel Visual Basic for Applications and database functionality on the share and firm data, was employed for the analysis.

Portfolios were grouped together into five quintiles based on the specified style variable, in this instance ‘percentage total asset growth’, which was used to represent firm investment. Each quintile represented 20% of the sample. The researcher then determined the subsequent return for each quintile portfolio.

Time-series analysis over different time horizons was conducted. The changes in firm investment, firm characteristic variables, and share returns over time were then analysed, and from this analysis associations and inferences were determined.

## 4.4 Time horizon

The time horizon for this study was longitudinal, formulated to understand changes in the operational variables over time. Time-series data between 30 September 1987 and 31 March 2019 across the main board of the JSE was modelled. Data was collected and analysed every quarter over the study period on firm financial and market variables. There were start-up issues in the early years, and data from later years was used in some of the analysis.

## 4.5 Unit of analysis, population and sample

The unit of analysis was ‘the firm’ and the study population was listed firms on the JSE. This study analysed the 160 largest firms at the end of each quarter between 30 September 1987 and 31 March 2019. Financial services and mining firms were excluded from the study, as their valuation methodologies differ from the discounted cash flow methods employed on account of the nature of their businesses. The value of a mine is strongly dependent upon commodity prices, the size of the ore, and the life of the mine (see Evatt, Johnson, Duck, & Howell, 2010). Financial services firms, on the other hand, are highly regulated, and their valuation and investment strategies are strongly constrained by regulatory requirements (Damodaran, 2013). Previous studies of the I–R ‘anomaly’ have also excluded financial services firms for similar reasons (Alti & Tetlock, 2014; Anderson & Garcia-Feijóo, 2006; Cooper & Priestley, 2011; Cooper et al., 2008; Lam & Wei., 2011; Lipson et al., 2011; Titman et al., 2013). Other than this exclusion, the sample was heterogeneous and spanned a range of industries.

A snapshot of the market sectors of the JSE and the firms listed on the JSE is provided below in Table 4.1 and Table 4.2.

**Table 4.1: All firms on the JSE at the end of 2017 (31 December 2017)**

Sector	Number of firms	Market capitalisation (ZAR million)	Percentage market capitalisation
Basic resources	56	2 800 502	18.8304%
Chemicals	8	313 217	2.1061%
Consumer goods	25	5 230 272	35.1681%
Consumer services	49	2 344 469	15.7641%
Financials	131	2 796 871	18.8060%
Fixed line telecoms	2	25 378	0.1706%

Sector	Number of firms	Market capitalisation (ZAR million)	Percentage market capitalisation
Healthcare	10	305 655	2.0552%
Industrials	68	464 775	3.1251%
Mobile telecoms	4	522 865	3.5157%
Oil and gas	5	18 771	0.1262%
Technology	15	49 381	0.3320%
Utilities	1	51	0.0003%
<b>Total</b>	<b>374</b>	<b>14 872 207</b>	<b>100.0000%</b>

**Source: Iress (2018)**

**Table 4.2: Largest 160 firms on the JSE at the end of 2017 (excluding mining and financial services) (31 December 2017)**

Sector	Number of firms	Market capitalisation (ZAR million)	Percentage market capitalisation
Chemicals	6	313 145	3.3%
Consumer goods	21	5 230 102	55.2%
Consumer services	41	2 344 148	24.7%
Fixed line telecoms	1	25 357	0.3%
Healthcare	9	305 618	3.2%
Industrials	57	464 021	4.9%
Mobile telecoms	4	522 865	5.5%
Oil and gas	5	18 771	0.2%
Pulp and paper	3	204 911	2.2%
Technology	13	49 299	0.5%
<b>Total</b>	<b>160</b>	<b>9 478 237</b>	<b>100.0%</b>

**Source: Iress (2018)**

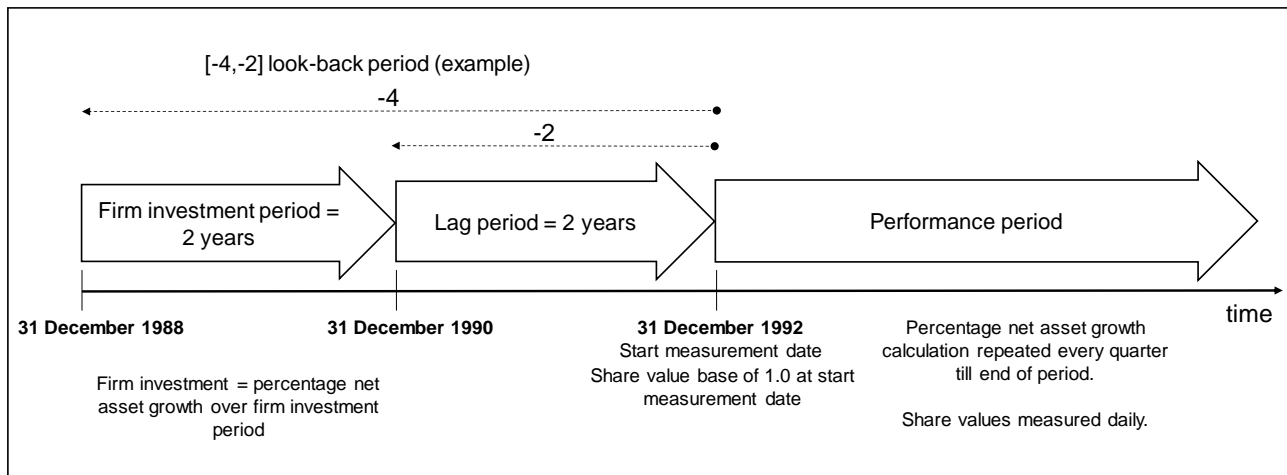
## **4.6 Data**

This study used secondary JSE share data and firm financial data in the form of annual financial statements and share return data (prices and dividends). The style engine used JSE share price data, dividend data and annual financial statement data from the financial data company Iress, a provider of continuous financial data feeds, including share price data, company financial statements and annual reports (Iress, 2018). Data was collected quarterly on a continuous basis from the database, and the style engine database reflected South African financial data starting from 30 September 1987 to 31 March 2019. At each quarter over this period (30 September 1987 to 31 March 2019), the top 160 firms on the JSE ranked by market capitalisation were analysed. This sample did not contain any firms from the financial services or mining sector. Specific data for this study was generated from this database, and daily share total returns from the JSE, together with financial statement data from Iress, were used in the analysis.

The procedure taken to eliminate survivorship bias was that newly listed shares were included at the start of each quarter, and delisted shares were removed at the end of the quarter based on their last price prior to cessation of trading.

## **4.7 Firm investment process**

The investment process comprised three periods that could vary depending on the project – the ‘firm investment period’, the ‘lag period’ and the ‘performance period’. The firm investment period was the period during which the investment was made. The lag period followed the firm investment period before the firm realised the benefit from the investment. The performance period follows the lag period during which the firm realises the benefit from the investment. The measurement of benefit started from the beginning of the performance period. This process was measured through the look-back framework which is illustrated in Figure 4.1 below.



**Figure 4.1: Investment process variables and illustration of 'look-back' parameters [-4,-2] example)**

**Source: Researcher's own model**

The 'look-back' period uses the firm investment period and lag period indicated as [-firm investment commencement, -lag period]. For example [-4,-2] at the 31 December 1992 returns measurement date, means to commence measurement of firm investment four years before the measurement date (which, in this example, was 31 December 1988) through to two year before the measurement date (which, in this example, is 31 December 1992) (i.e. a two-year period to measure the investment in assets and a two-year lag between the investment in assets and the measurement of subsequent returns).

In this example, the style variable was calculated for each share in the sample as the percentage net asset growth over the two-year investment period (starting 31 December 1988). This was followed by a two-year lag to 31 December 1990. The starting date for the return measurement was 31 December 1992. The value of each of each share was calculated daily from a base of 1.0. (starting 31 December 1992).

Shares were ranked by the style variable (percentage net asset growth) and allocated into five (quintile) portfolios, each equally weighted. Each quintile represented 20% of the sample. Quintile 1 (Q1) was the portfolio containing the shares with the highest percentage net asset growth, and quintile 5 (Q5) was the portfolio containing the shares with the lowest percentage net asset growth. The performance of each quintile was then monitored daily, with dividends assumed to be reinvested.

These quintiles are calculated every consecutive quarter. At the end of each quarter, the quintiles were rebalanced. Shares entering or leaving the market were identified, and the 160 largest shares

were selected. The style variable was re-calculated, and shares ranked accordingly and re-allocated into quintiles on an equally weighted basis. This approach was repeated each quarter, accumulating the daily value of each portfolio, until the end of the period.

## 4.8 Operationalisation of variables

The key constructs and operational variables used in the study are defined below.

**Table 4.3: Definition of operational variables**

<b>Variable</b>	<b>Definition</b>
<b>Book-to-market ratio:</b>	The book value of equity divided by the market value of equity.
<b>Debt-to-equity ratio:</b>	The debt-to-market value of equity ratio.
<b>Equity issuance:</b>	The value of new equity issued divided by the market equity value of the firm, as a percentage.
<b>Firm investment:</b>	The percentage change in net assets over the firm investment period, using a linear method of measurement or LOGEST method of measurement. Net assets are the total book value of the assets excluding trade payables and deferred tax.
<b>Firm investment period:</b>	The period over which the capital is invested.
<b>Lag period:</b>	The delay period after the firm investment period over which no benefit in share return is measured. The share return is measured after the lag period.
<b>Look-back:</b>	The 'look-back' period is a function of the firm investment period and lag period variables
<b>Market capitalisation or market value:</b>	The market value of the equity of the firm.
<b>Profitability:</b>	Net income divided by book value (ROE measure).

Variable	Definition
<b>Share return:</b>	The percentage change in the market equity value of the firm over a period, including dividends. The market value of equity is the closing share price multiplied by the number of shares outstanding.
<b>Size:</b>	The natural log of market capitalisation.

**Source: Researcher's analysis and Semnarayan et al. (2018)**

## **4.9 Research procedures**

This section describes the procedures undertaken to test each hypothesis in turn. The effect of investment and lag periods was firstly determined on the highest and lowest investment portfolios. A 'optimal' case of the highest and lowest investment portfolios was chosen, based on the maximum negative return difference between the highest and lowest investment portfolios. The significance of the negative return was tested on the optimised case. Further cases with different investment and lag periods were formulated, and the characteristics of these cases with respect to abnormal effects were then analysed.

### ***4.9.1 I–R relationship, investment and lag periods***

The steps used in the style engine for the initial phase are summarised below, and are also presented in Semnarayan et al. (2018). This initial phase was to determine whether the I–R relationship was evident on the JSE. The results of this initial phase were also presented in Semnarayan et al. (2018). The initial phase assumed a notional starting investment and lag period of [-4,-2] (using the linear measure of firm investment) and, using the style engine, the subsequent share returns of the equal-weighted quintiles were processed to determine whether the I–R relationship was evident on the JSE. Data from 31 December 1988 to 31 December 2016 was analysed.

For the initial phase, the parameters of the look-back period were arbitrarily fixed as [-4,-2]. At each point only the top 160 firms on the JSE ranked by market capitalisation were analysed. This sample did not contain any firms from the financial services and mining sector, which were excluded. The style variable was then calculated for each share in the sample as the percentage net asset growth over the two-year investment period (starting 31 December 1988). This was followed by a two-year lag to 31 December 1990. The starting date for the return measurement was 31 December 1992.

The value of each of each share was calculated daily from a base of 1.0. (starting 31 December 1992). Shares were ranked by the style variable (percentage net asset growth) and allocated into five (quintile) portfolios, each equally weighted. Each quintile represented 20% of the sample. Quintile 1 (Q1) was the portfolio containing the shares with the highest percentage net asset growth, and quintile 5 (Q5) was the portfolio containing the shares with the lowest percentage net asset growth. The performance of each quintile was then monitored daily, with dividends assumed to be reinvested. At the end of each quarter, the quintiles were rebalanced. Shares entering or leaving the market were identified, and the 160 largest shares were selected. The style variable was re-calculated, and shares ranked accordingly and re-allocated into quintiles on an equally weighted basis. This approach was repeated each quarter, accumulating the daily value of each portfolio, until the end of the period.

Refer to hypothesis 1 formulated in section 3.5.1, and restated below. The null hypothesis ( $H1_0$ ) and the alternative hypothesis ( $H1_a$ ) tested were derived from this hypothesis. The testing procedure is described below.

Hypothesis 1: The relationship between firm investment and subsequent share return is dependent on the investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

The null hypothesis ( $H1_0$ ) tested was that the relationship between firm investment, and share return, is not dependent on the investment period and lag period; in a context of high-risk, low-turnover, and high-volatility conditions.

The alternative hypothesis ( $H1_a$ ) tested was that the relationship between firm investment, and share return, is dependent on the investment period and lag period; in a context of high-risk, low-turnover, and high-volatility conditions.

To test this hypothesis ( $H1$ ), the following process was followed using the style engine. The cumulative share return for varying look-back periods (capex periods 1 year to 10 years, and lag periods of 1 year to 10 years) for the highest investment portfolio Q1 and for the lowest investment portfolio Q5 were determined. Firm investment was calculated employing the LOGEST measure. The data was analysed from 31 December 1995 to 31 March 2019. The following process was followed determine the matrix of cumulative share returns for Q1 and Q5 for each look-back period. The parameters of the first look-back period was chosen. At each point only the top 160 firms on the JSE ranked by market capitalisation were analysed; with firms in financial services and mining sector excluded from this sample. The style variable was then calculated for each share in the sample as



the percentage net asset growth over the chosen investment period. This was followed by the lag period. The starting date for the return measurement was based on the investment and lag period. The value of each of each share was calculated daily from a base of 1.0 at the start date. Shares were ranked by the style variable (percentage net asset growth) and allocated into five (quintile) portfolios, each equally weighted. Each quintile represented 20% of the sample. Quintile 1 (Q1) was the portfolio containing the shares with the highest percentage net asset growth, and quintile 5 (Q5) was the portfolio containing the shares with the lowest percentage net asset growth. The performance of each quintile was then monitored daily, with dividends assumed to be reinvested. At the end of each quarter, the quintiles were rebalanced. Shares entering or leaving the market were identified, and the 160 largest shares were selected. The style variable was re-calculated, and shares ranked accordingly and re-allocated into quintiles on an equally weighted basis. This approach was repeated each quarter, accumulating the daily value of each portfolio, until the end of the period. This process then repeated for the next look-back period.

(Semnarayan et al. (2018) employed the linear measure to analyse the relationship between I–R, investment and lag periods, and these results are shown in Appendix A.)

#### ***4.9.2 Significant negative I–R relationship***

Refer to hypothesis 2 formulated in section 3.5.2, and restated below. The null hypothesis ( $H_{2_0}$ ) and alternative hypothesis ( $H_{2_a}$ ) tested were derived from this hypothesis. The testing procedure is described below.

Hypothesis 2: There is a significant negative relationship between firm investment and subsequent share return, which is dependent on the investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

The null hypothesis ( $H_{2_0}$ ) tested was that the negative relationship between firm investment, and share return is not significant, which is dependent on the investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

The alternative hypothesis ( $H_{2_a}$ ) tested was that there is a significant negative relationship between firm investment, and share return, which is dependent on the investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

Based on the results of the above analysis (see section 4.9.1), two portfolios were selected as the ‘optimised’ case, based on the maximum negative return difference between the highest and lowest investment portfolios. The Q1 portfolio with the lowest cumulative share return and the Q5 portfolio

with the highest cumulative share return, from the results from section 4.9.1 was selected as the 'optimised' case. The significance of the negative I–R relationship was determined by comparing these portfolios, using two methods – the bootstrap test using the style engine and the paired sample-t test with bootstrap discussed below.

(Semnarayan et al. (2018) employed the linear measure to analyse the significance of the negative I–R relationship and these results are shown in Appendix A.)

In time series, there is autocorrelation, where each subsequent observation is equal to the previous observation plus a random disturbance, and the observations are random (not independent) (Jeong & Chung, 2001). Bootstrap uses the actual observations by means of repeated sampling to calculate the significance of the difference (Jeong & Chung, 2001). The bootstrap test using the style engine was used to test the significance of the negative I–R relationship (hypothesis 2). This test determines whether the cumulative share return of the low-investment portfolio was significantly higher (at a 95% confidence level) than the share return of the high-investment portfolio, relative to profiles based on random styles.

From a statistical perspective, the power and benefits of the style engine rest on two main aspects: the use of equally weighted portfolios to reduce the noise in the data from individual shares, and the accumulation of the tiny daily differences in returns over a study period, which facilitates visualising and measuring the impact of the style strategy.

Accordingly, a bootstrap distribution was constructed, based on 100 random samples, to test for the statistical significance of the difference between Q1 and Q5, since these series were autocorrelated and cumulative. The bootstrap distribution was constructed with the style engine following the same process and data described above, except that the style variable (percentage net asset growth) was replaced by a random number, drawn from a continuous, uniform distribution. The rank was random, but the companies in the sample at each re-balancing were identical. Although the individual company returns were identical, the daily portfolio returns differed, as these were based on randomly constructed equally weighted portfolios. The style engine was re-run 100 times, to construct 100 random cumulative total return indices for each quintile. These were then ranked by their final year cumulative return, identifying the 5<sup>th</sup> and 95<sup>th</sup> percentile cumulative return lines (indices) and plotting these confidence limits together with the Q1 and Q5 percentage net asset growth styles.

This method is superior to standardised parametric or non-parametric tests, and other statistical software cannot construct a comparable style-based bootstrap distribution.

Paired samples t-test, with the bootstrap function enabled on the IBM SPSS software platform was an additional test performed to test for the significance of the negative I–R relationship. Paired sample t-testing with bootstrap gives valid results in spite of autocorrelation in the time series data.

#### **4.9.3 I–R association with abnormal effects**

Refer to hypothesis 3 formulated in section 3.5.3 restated below.

Hypothesis 3.1: The I–R relationship is associated with the book-to-market abnormal effect, which is dependent on investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

Hypothesis 3.2: The I–R relationship is associated with the size abnormal effect, which is dependent on investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

Hypothesis 3.3: The I–R relationship is associated with the equity issuance effect, which is dependent on investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

Hypothesis 3.4: The I–R relationship is associated with the debt-to-market equity effect, which is dependent on investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

Hypothesis 3.5: The I–R relationship is associated with the profitability effect, which is dependent on investment period and lag period in a context of high-risk, low-turnover, and high-volatility conditions.

In order to test these hypotheses, cases were formulated with different look-back periods, and the significance of the associations to I–R were compared between these different cases for each of the effects.

The cases were formulated as follows:

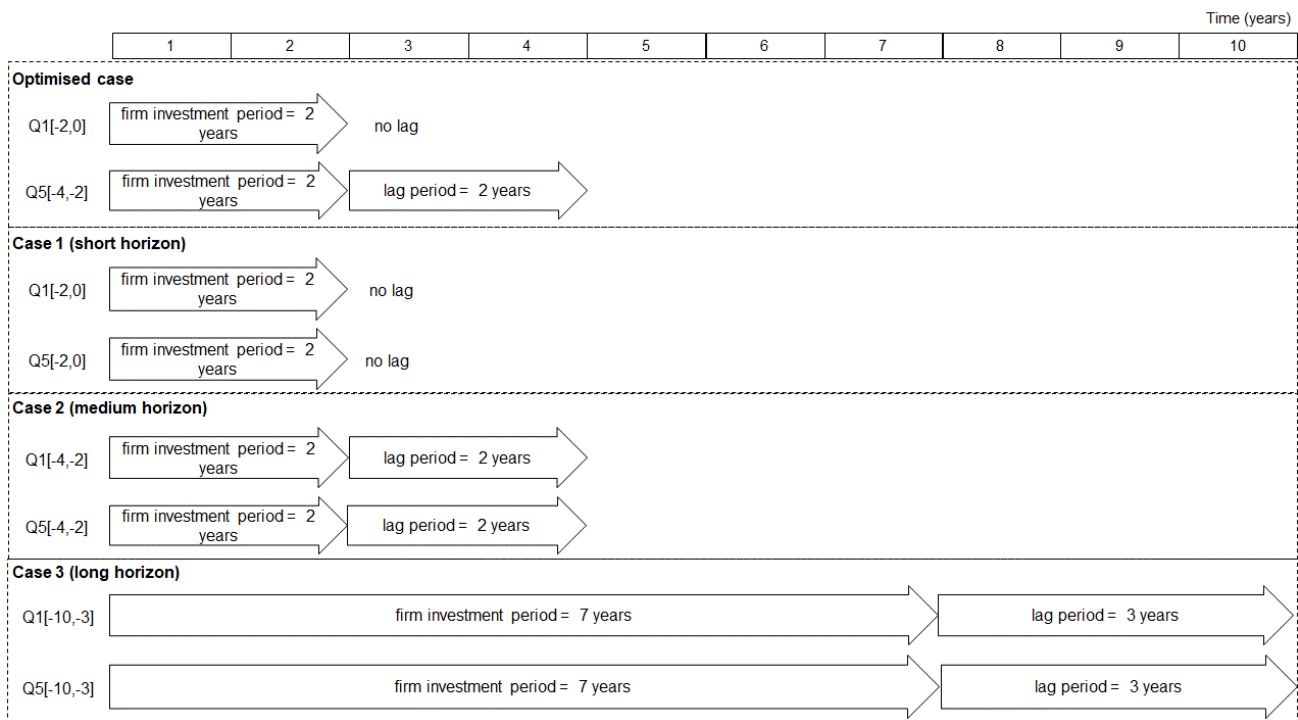
- **Case 1 (short horizon) with Q1[-2,0] and Q5[-2,0]:** Q1[-2,0] was the portfolio with the highest firm investment, and that had a firm investment period of 2 years and no lag. Q1[-2,0] was the portfolio with a relatively short investment period and relatively short lag period. Q5[-2,0] was the portfolio with the lowest firm investment, and that had a firm investment period of 2 years and no lag. Q5[-2,0] was the portfolio with a relatively short investment period and relatively short lag period.

- **Case 2 (medium horizon) with Q1[-4,-2] and Q5[-4,-2]:** Q1[-4,-2] was the portfolio with the highest firm investment, and that had a firm investment period of 2 years and a lag period of 2 years. Q1[-4,-2] was the portfolio with a relatively medium investment period and relatively medium lag period. Q5[-4,-2] was the portfolio with the lowest firm investment, and that had a firm investment period of 2 years and a lag period of 2 years. Q5[-2,0] was the portfolio with a relatively medium investment period and relatively medium lag period.
- **Case 3 (long horizon) with Q1[-10,-3] and Q5[-10,-3]:** Q1[-10,-3] was the portfolio with the highest firm investment, and that had a firm investment period of 7 years and a lag period of 3 years. Q1[-10,-3] was the portfolio with a relatively long investment period and relatively long lag period. Q5[-10,-3] was the portfolio with the lowest firm investment, and that had a firm investment period of 7 years and a lag period of 3 years. Q5[-10,-3] was the portfolio with a relatively long investment period and relatively long lag period..

The 'optimised' case formulated (see section 4.9.2 and section 5.2) was also selected as a case:

- **Optimised case with Q1[-2,0] and Q5[-4,-2]:** Q1[-2,0] was the portfolio with the highest firm investment, and that had a firm investment period of 2 years and no lag. Q5[-4,-2] was the portfolio with the lowest firm investment, and that had a firm investment period of 2 years and a lag period of 2 years. Q1[-2,0] was the portfolio with the lowest cumulative share return (4.96%) in Figure 5.2. Q5[-4,-2] was the portfolio with the highest cumulative share return (16.69%) in Figure 5.3.

Figure 4.2 illustrates the different cases that were compared.



**Figure 4.2: Illustration of cases**

Sub-hypotheses listed below were tested over these four cases for each effect. Paired samples t-test with bootstrap for autocorrelation was used to test the difference in these effects between Q1 and Q5 for the different cases.

The null hypotheses tested was that there is no significant association between:

- (H3.1.1<sub>0</sub>) I-R and book-to-market (optimised case)
- (H3.1.2<sub>0</sub>) I-R and book-to-market (short horizon case)
- (H3.1.3<sub>0</sub>) I-R and book-to-market (medium horizon case)
- (H3.1.4<sub>0</sub>) I-R and book-to-market (long horizon case)
- (H3.2.1<sub>0</sub>) I-R and size (optimised case)
- (H3.2.2<sub>0</sub>) I-R and size (short horizon case)
- (H3.2.3<sub>0</sub>) I-R and size (medium horizon case)
- (H3.2.4<sub>0</sub>) I-R and size (long horizon case)
- (H3.3.1<sub>0</sub>) I-R and equity issuance (optimised case)
- (H3.3.2<sub>0</sub>) I-R and equity issuance (short horizon case)
- (H3.3.3<sub>0</sub>) I-R and equity issuance (medium horizon case)
- (H3.3.4<sub>0</sub>) I-R and equity issuance (long horizon case)
- (H3.4.1<sub>0</sub>) I-R and debt-to-market equity (optimised case)

- (H3.4.2<sub>0</sub>) I–R and debt-to-market equity (short horizon case)
- (H3.4.3<sub>0</sub>) I–R and debt-to-market equity (medium horizon case)
- (H3.4.1<sub>0</sub>) I–R and debt-to-market equity (long horizon case)
- (H3.5.1<sub>0</sub>) I–R and profitability (optimised case)
- (H3.5.1<sub>0</sub>) I–R and profitability (short horizon case)
- (H3.5.1<sub>0</sub>) I–R and profitability (medium horizon case)
- (H3.5.1<sub>0</sub>) I–R and profitability (long horizon case)

The alternative hypothesis (H4<sub>a</sub>) tested was that there is a significant association between

- (H3.1.1<sub>a</sub>) I–R and book-to-market (optimised case)
- (H3.1.2<sub>a</sub>) I–R and book-to-market (short horizon case)
- (H3.1.3<sub>a</sub>) I–R and book-to-market (medium horizon case)
- (H3.1.4<sub>a</sub>) I–R and book-to-market (long horizon case)
- (H3.2.1<sub>a</sub>) I–R and size (optimised case)
- (H3.2.2<sub>a</sub>) I–R and size (short horizon case)
- (H3.2.3<sub>a</sub>) I–R and size (medium horizon case)
- (H3.2.4<sub>a</sub>) I–R and size (long horizon case)
- (H3.3.1<sub>a</sub>) I–R and equity issuance (optimised case)
- (H3.3.2<sub>a</sub>) I–R and equity issuance (short horizon case)
- (H3.3.3<sub>a</sub>) I–R and equity issuance (medium horizon case)
- (H3.3.4<sub>a</sub>) I–R and equity issuance (long horizon case)
- (H3.4.1<sub>a</sub>) I–R and debt-to-market equity (optimised case)
- (H3.4.2<sub>a</sub>) I–R and debt-to-market equity (short horizon case)
- (H3.4.3<sub>a</sub>) I–R and debt-to-market equity (medium horizon case)
- (H3.4.1<sub>a</sub>) I–R and debt-to-market equity (long horizon case)
- (H3.5.1<sub>a</sub>) I–R and profitability (optimised case)
- (H3.5.1<sub>a</sub>) I–R and profitability (short horizon case)
- (H3.5.1<sub>a</sub>) I–R and profitability (medium horizon case)
- (H3.5.1<sub>a</sub>) I–R and profitability (long horizon case)

#### **4.10 Quality assurance**

The style engine was built and tested to minimise bias and to ensure the validity, reliability and replicability of the results. This section discusses how the current research deal with share splits, consolidations, dividend receipts, share buybacks, newly listed shares, delisted shares, look-ahead

bias and shares issued to managers. These quality assurance measures are also presented in Semnarayan et al. (2018).

The operational variables were selected on previous research (see Anderson & Garcia-Feijóo, 2006; Berk et al., 1999; Cochrane, 1991, 1996; Cooper & Priestley, 2011; Hou et al., 2015; Kumar & Li, 2016; Liu et al., 2009; Xing, 2008; Zhang, 2005; Zhang, 2017). Financial and accounting data that meet JSE requirements was used in the current study.

Changes in share prices resulting from share splits or consolidations were adjusted backwards in the time series data. Where a firm unbundled (spun off) a subsidiary, the returns of the newly listed subsidiary were combined with those of the original holding firm for the remainder of the quarterly review period. Thereafter the firms were treated as separate entities.

Dividend receipts constitute a significant portion of the return an investor receives, and the style engine therefore included dividends in share reruns using the historical time series of cash (and scrip) dividend payouts.

Share buybacks were not accounted for, because these were a form of capital reduction that only affected those shareholders who exited the company over the study period.

Survivorship bias occurs when shares that have closed or delisted are not accounted for in the sample according to Elton, Gruber and Blake (1996). Elton et al. (1996) show that this can inflate performance and lead to incorrect results. Survivor bias was eliminated in the current study, through the mechanism whereby newly listed shares were included at the start of each quarter, and delisted shares were removed at the end of the quarter based on their last price prior to cessation of trading.

With regards to outliers, outliers were checked and remedied. Name changes were tracked and followed through in the sample. In rare instances where daily returns on shares were less than -40% or greater than +40%, these points in the time-series were omitted, as there were certainly errors in the data for those points.

Look-ahead bias could potentially cause errors (Baquero, ter Horst, & Verbeek, 2005). To avoid this, the analysis should be based on information that is available at the time of the trade (Baquero et al., 2005). Look-ahead bias was factored into the style engine by including a three-month delay from company year-end to incorporating the data into the analysis. This allowed the current research to take into account the delay in the publication of the financial results of the firm versus its year-end date.

Shares granted as compensation to managers were considered immaterial, and were ignored.

#### **4.11 Reliability and validity**

Several quality assurance measures were implemented in the style engine (see section 4.10). The study employed secondary, publically available JSE-published data. The research procedures are clearly defined. Different measures of firm investment were employed. To deal with the potential problem of autocorrelation, bootstrap on the JSE data was employed to test for significance. In addition paired t-tests with bootstrap function was used. The use of portfolios could create a problem of aggregation, as measures of median or averages of the portfolios were employed, and there could have been other influencing factors. However, the construct of investment style was specified distinctly and clearly. Statistical tests were conducted to test for significance at a high confidence level.

#### **4.12 Limitations of the study**

The limitations of the study are listed below –

- Portfolios were studied, raising the possibility of some aggregation effect.
- There were start-up issues in the data, which were not interrogated in depth.
- The investment CAPM model was not tested with respect to all its aspects.

Finally, all of these limitations lay the foundations for relevant future research, and these are noted in section 7.6.

#### **4.13 Ethical considerations**

Ethical considerations in management research include the right to privacy, confidentiality, anonymity, ensuring objectivity and quality of research (Bell & Bryman, 2007). The researcher kept these considerations in mind at all stages of the research. Data was not gained from any human participants during the study; instead, secondary, publically available JSE share and firm financial data from Iress (as discussed above) was employed. The researcher, through his affiliation with the study university, had the right to use this data for research purposes. There is no misrepresentation of data or analysis. The confidentiality and privacy of firms were ensured, as the study was based on analysing portfolios of firms, and the names of companies were not relevant and are not mentioned in the research report.



## Chapter 5: Results

In this chapter, section 5.1 presents the analysis of the relationship between firm investment and subsequent share return, with the varied look-back periods, using the LOGEST measure of firm investment. This answers hypothesis 1. Semnarayan et al. (2018) also presented some of the results using the linear measure of firm investment and these results are shown in Appendix A.

The investment period and lag period were 'optimised' for the highest investment and lowest investment portfolios, based on the results from section 5.1. The optimised case was based on maximising the difference in returns between the portfolios. Section 5.2 presents the significance of the negative I–R relationship. Semnarayan et al. (2018) also presented some of the results using linear measure of firm investment and these results are shown in Appendix A. This answers hypothesis 2.

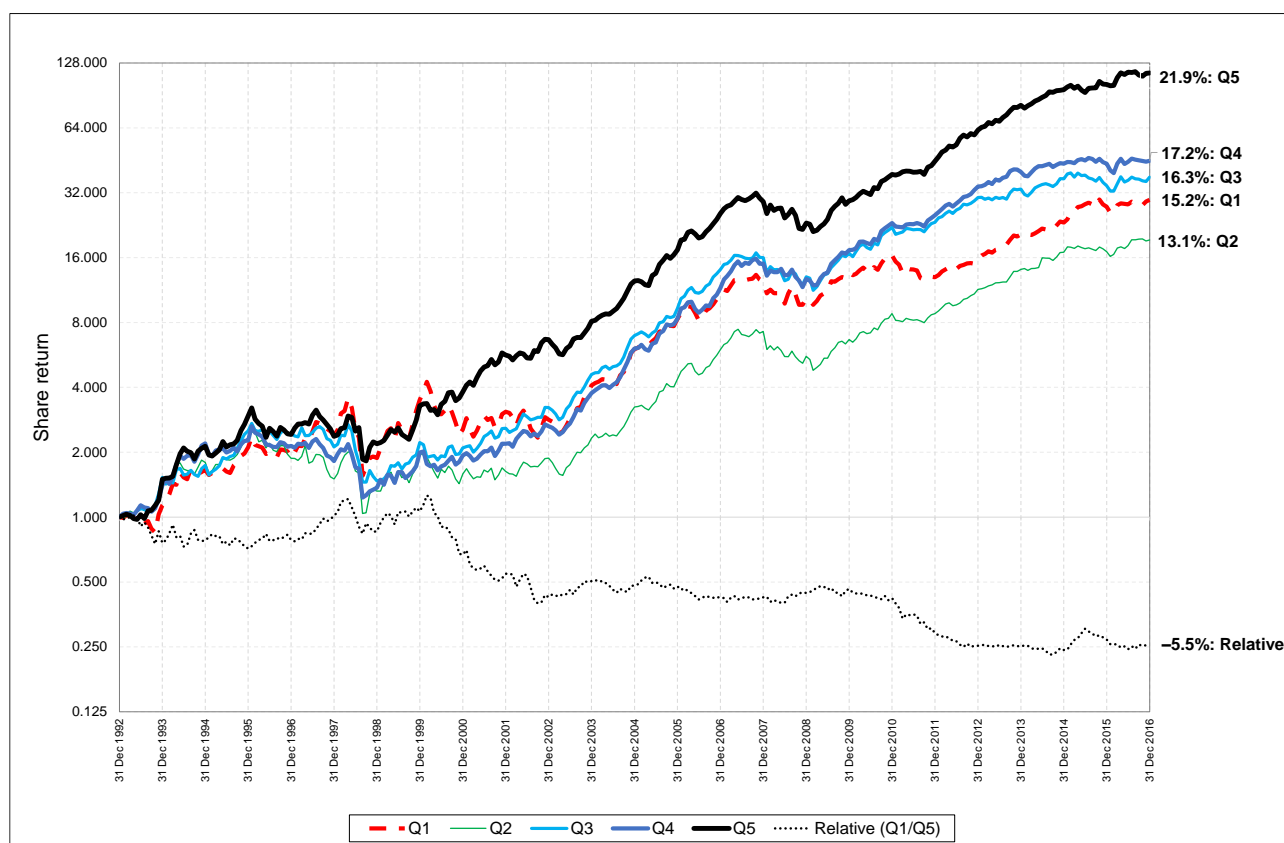
Different cases were formulated with varying investment and lag periods. Section 5.3 compares the characteristics of abnormal effects of value-versus-growth, size, equity issuance, debt-to-market equity, and profitability between the different cases with relation to I–R. This answers hypotheses 3.1–3.5. Section 5.4 summarises the results.

(Note: The source for all figures in this chapter is the researcher's data and analysis. The source for all tables is the researcher's data and analysis).

### 5.1 I–R relationship, investment and lag periods

The results of the initial phase to determine whether the I–R relationship was evident on the JSE is reported in the following section.

This section shows the results of initial phase – share return results of quintiles 1 to 5, each with a look-back of  $[-4, -2]$ , sorted on firm investment. Figure 5.1 below reflects the daily share value (indexed from 1.0) of each of the quintiles over the period 31 December 1992 to 31 December 2016. Quintile 1 (Q1) comprises those shares with the highest asset growth; quintile 2 (Q2) those with the second highest asset growth; quintile 3 (Q3) those with the third highest asset growth; quintile 4 (Q4) those with the fourth highest asset growth; and quintile 5 (Q5), the portfolio with the lowest asset growth. This procedure was used to determine the relative difference in share returns between the quintiles ranked on firm investment, all with a  $[-4, -2]$  look-back period.



**Figure 5.1: Quintiles ranked on firm investment (with look-back [-4,-2])**

Figure 5.1 indicates how portfolios with lower firm investment result in a higher cumulative share return over the period 31 December 1992 to 31 December 2016, except for the two quintiles (Q1 and Q2) with the highest firm investments. The cumulative return for Q1 was slightly higher than that for Q2 over the period 31 December 1992 to 31 December 2016. The South African market was immature and closed in the early start-up years pre-1999 (Financial Times, 2017; Marketline, 2017; The World Bank, 2017) suggesting this could be related to start-up issues. Quintiles Q1 and Q2 tracked each other from around 31 December 1999 to around 31 December 2010. The gap between Q1 and Q2 was broadly similar from around 31 December 1999 to around 31 December 2010, and this gap between Q1 and Q2 narrowed after around 31 December 2010, by which time the market was more mature and open.

The price relative line 'Relative' represents the ratio of Q1 to Q5 over the period 31 December 1992 to 31 December 2016. The price relative was around 1.0 between 31 December 1992 and 31 December 1999. It steadily declined between 31 December 1992 and 31 December 2002. The price relative further declined between 31 December 2009 and 31 December 2016, culminating in a relative difference of 5.5% between these two portfolios (Q1 and Q5) over the period. This relative price difference implies that an investor taking a long or short position on these portfolios would have

yielded 5.5% per annum over the period. The investor could have taken a long position on the portfolio with the lowest firm investment (Q5), and at the same time take a short position on the portfolio with the highest firm investment (Q1), in this case. This option strategy over these two portfolios would have yielded an annual return premium of 5.5% over the period 31 December 1992 to 31 December 2016. If an investor held firms in the Q5 portfolio, and at the same time sold firms in the Q1 portfolio, the investor would have achieved a 5.5% premium over this period, on aggregate, based on the relative difference in the cumulative share returns of these portfolios. Based on this analysis there was evidence that the negative I–R relationship was present on the JSE.

The results of Q1 and Q5 with varying look-back periods using the LOGEST measure of firm investment is reported in the following section.

Figure 5.2 shows the annualised share returns for the quintile with the highest investment in capital for varying firm investment, lag and performance periods. The data was analysed from 31 December 1995 to 31 March 2019.

### Share returns for highest capital investment (LOGEST measure)

Capex end year		-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Capex start year	-1	x	x	x	x	x	x	x	x	x	8.39%
	-2	x	x	x	x	x	x	x	x	8.31%	4.96%
	-3	x	x	x	x	x	x	x	7.10%	7.45%	5.40%
	-4	x	x	x	x	x	x	8.22%	10.62%	7.00%	6.00%
	-5	x	x	x	x	x	8.47%	8.05%	8.85%	7.98%	6.09%
	-6	x	x	x	x	10.68%	12.56%	9.42%	9.37%	8.49%	6.61%
	-7	x	x	x	8.93%	11.60%	11.33%	10.40%	9.87%	8.48%	7.38%
	-8	x	x	9.50%	10.17%	10.92%	10.87%	10.53%	10.73%	8.68%	6.87%
	-9	x	10.05%	13.04%	11.74%	9.94%	10.66%	9.34%	9.43%	8.54%	6.74%
	-10	10.62%	12.81%	13.05%	10.84%	10.21%	10.83%	9.50%	9.90%	9.31%	6.18%

**Figure 5.2: Share returns for the highest firm investment quintile (LOGEST measure of firm investment)**

From Figure 5.2, returns were lower (red) for firms that had invested in capital in more recent years than for firms that invested in capital in the earlier years (green). For the quintile with the highest investment in capital, share returns would have best (green) if the investments were made starting 9 or 10 years ago, with a long lag of 7 to 8 years. For the quintile with the highest investment in capital, share returns would have been worst (red) if the investments were made over the last 4 years. The worst (lowest) result from Figure 5.2 was 4.96% per annum. This was for firms with a [-2,0] look-back period (i.e. firms that commenced with firm investment 2 years before, with a firm investment period of 2 years, and no lag). Q1 was constructed later, using this optimised [-2,0] look-back period. The highest result from Figure 5.2 was 13.05% per annum, which was for firms with a

[-10,-7] look-back period (i.e. firms that commenced with firm investment 10 years before, with a firm investment period of 3 years, and a 7-year lag).

#### Share returns for lowest capital investment (LOGEST measure)

Capex end year		-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Capex start year	-1	x	x	x	x	x	x	x	x	x	13.47%
	-2	x	x	x	x	x	x	x	x	14.18%	16.29%
	-3	x	x	x	x	x	x	x	12.26%	13.97%	16.01%
	-4	x	x	x	x	x	x	13.36%	16.69%	13.76%	15.95%
	-5	x	x	x	x	x	14.75%	14.68%	15.85%	14.37%	14.86%
	-6	x	x	x	x	14.30%	12.14%	14.88%	13.34%	13.24%	15.51%
	-7	x	x	x	12.70%	11.69%	12.92%	15.32%	13.28%	13.78%	15.50%
	-8	x	x	12.03%	12.88%	13.31%	12.76%	13.30%	13.39%	13.65%	14.64%
	-9	x	11.01%	10.75%	15.88%	13.52%	12.30%	13.13%	13.57%	13.59%	12.94%
	-10	12.41%	9.78%	13.02%	14.35%	11.38%	12.01%	13.03%	12.06%	13.32%	11.59%

**Figure 5.3: Share returns for the lowest firm investment quintile (LOGEST measure of firm investment)**

From Figure 5.3, returns are higher (green) for firms, which invested the least in recent periods, particularly the previous 3 years, than for firms that invested the least earlier. The highest result from Figure 5.3 is 16.69% per annum. This was for firms with a [-4,-2] look-back period (firms that commenced capex 4 years previously, with a capex period of 2 years, and a lag of 2 years). Q5 was constructed later using this [-4,-2] look-back period. The lowest result from this figure is 9.78% per annum, which represents a [-10,-8] look-back period (firms that commenced with capex 10 years

before, with a capex period of 2 years, and a lag period of 8 years prior to the returns measurement date) from Figure 5.3.

Difference of share returns (lowest capital investment minus highest capital investment) (LOGEST measure)											
Capex end year											
Capex start year		-9	-8	-7	-6	-5	-4	-3	-2	-1	0
	-1	x	x	x	x	x	x	x	x	x	5.08%
	-2	x	x	x	x	x	x	x	x	5.87%	11.33%
	-3	x	x	x	x	x	x	x	5.16%	6.53%	10.61%
	-4	x	x	x	x	x	x	5.14%	6.07%	6.77%	9.95%
	-5	x	x	x	x	x	6.27%	6.62%	7.00%	6.39%	8.78%
	-6	x	x	x	x	3.62%	-0.42%	5.46%	3.97%	4.75%	8.91%
	-7	x	x	x	3.77%	0.10%	1.59%	4.92%	3.40%	5.30%	8.12%
	-8	x	x	2.53%	2.71%	2.39%	1.89%	2.77%	2.66%	4.97%	7.77%
	-9	x	0.95%	-2.29%	4.14%	3.58%	1.64%	3.79%	4.14%	5.05%	6.20%
	-10	1.79%	-3.03%	-0.02%	3.51%	1.16%	1.18%	3.54%	2.16%	4.02%	5.41%

**Figure 5.4: Difference of share returns between the lowest firm investment quintile and the highest firm investment quintile (LOGEST measure of firm investment)**

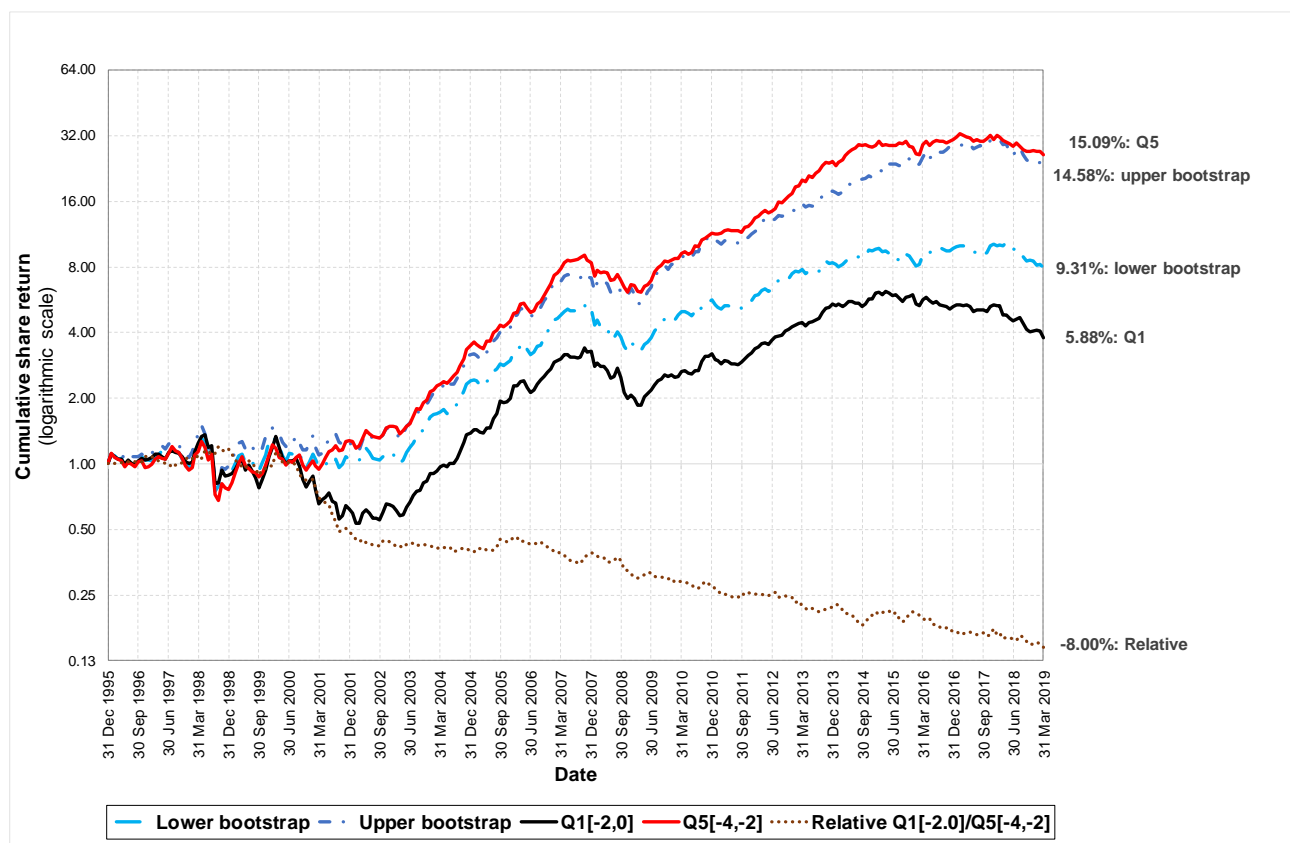
Figure 5.4 shows the differences in share return between the lowest firm investment and the highest firm investment portfolios. From Figure 5.4, it is clear that the difference between cumulative returns for high firm investment and low firm investment portfolios depends on the firm investment periods and lag periods. For shorter firm investment periods and shorter lag periods, returns were higher for the portfolio with lower firm investment. For longer firm investment periods and longer lag periods, returns were higher for the portfolio with higher firm investment. The relationship changed over time.

The study found that that the relationship between firm investment and subsequent share return was dependent on the investment period and lag period. The null hypothesis ( $H1_0$ ) was rejected.

## 5.2 Significant negative I–R relationship

The ‘optimised’ case was derived from the results of section 5.1. The cumulative share return of Q1[-2,0] was the lowest in Figure 5.2 at 4.96%, and the cumulative share return of Q5[-4,-2] was the highest in Figure 5.3 at 16.29%. For the LOGEST measure of firm investment, the significance of the difference in share returns between Q1[-2,0] and Q5[-4,-2] was determined.

Figure 5.5 shows the returns of Q1 (highest firm investment portfolio with [-2,0] look-back period) and Q5[-4,-2] (lowest firm investment portfolio with [-4,-2] look-back period), modelled on the LOGEST measure of firm investment.



**Figure 5.5: High-investment Q1[-2,0] and low-investment Q5[-4,-2] portfolios with confidence limits (LOGEST measure of firm investment)**

The quintile with companies investing the least (Q5[-4,-2]) shows a 15.09% per annum cumulative return over the period 31 December 1995 and 31 March 2019. Investing in firms that had the lowest capex over the previous 2 years gave the highest returns. The quintile with companies investing the most (Q1[-2,0]) shows a 5.88% per annum cumulative return over the period 31 December 1995 to

31 March 2019. Investing in firms that had the highest capex over the previous 2 years, gave the lowest returns.

The price relative 'Relative' represents the ratio of  $Q1[-2,0]$  to  $Q5[-4,-2]$  over the period. The price relative oscillates around 1.0 in the early start-up years between 31 December 1995 and 30 June 2000. The price relative decreases substantially between 30 June 2000 and 31 December 2001. Thereafter, the price relative decreases steadily between 31 December 2001 and 31 March 2019. The decline in the price relative was continuous and persistent between 30 June 2000 and 31 March 2019. This culminated in a relative difference of 8.00% between these two portfolios over the period 31 December 1995 and 31 March 2019. A long or short position would have yielded 8.00% per annum over the period, from these results. The investor could have taken a long position on the portfolio with the lowest firm investment ( $Q5[-4,-2]$ ), and have taken a short position on the portfolio with the highest firm investment ( $Q1[-2,0]$ ), in this case. This option strategy over these two portfolios would have yielded an annual return premium of 8.00% over the period. If an investor held firms in the Q5 portfolio, and at the same time sold firms in the Q1 portfolio, the investor would have achieved a 8.00% premium over this period, on aggregate, based on the relative difference in the cumulative share returns of these portfolios.

The significance of the difference of share return between these two portfolios,  $Q1[-2,0]$  and  $Q5[-4,-2]$  (that with highest firm investment and that with lowest firm investment) was then determined and Figure 5.5 shows the bootstrap results for Q1 and Q5 ('upper bootstrap' and 'lower bootstrap').

The 5<sup>th</sup> percentile return (upper bootstrap) was at 14.58% and the 95<sup>th</sup> percentile return (lower bootstrap) was at 9.31 percent. Q5 was significantly higher than 'upper bootstrap' at 15.09% per annum cumulative return over the period, and Q1 was significantly lower than 'lower bootstrap' at 5.88% per annum cumulative return over the period, showing both these to be statistically significant.

A paired sample t-test using bootstrap for autocorrelation was also performed. The difference between  $Q1[-2,0]$  and  $Q5[-4,-2]$  was significant, as shown in Table 5.1.



**Table 5.1: Paired samples test difference between Q1[-2,0] and Q5[-4,-2] (31 December 1995 to 31 March 2019)**

Paired samples test								
Pair	Paired differences					t-statistic	Degrees of freedom	Significance (2-tailed)
	Mean	Standard deviation	Standard error mean	95% confidence interval of the difference				
				Lower	Upper			
Q1[-2,0] - Q5[-4,-2]	-8.262	9.348	0.559	-9.362	-7.162	-14.788	279	0.000

It could be concluded that the share returns of portfolios with lower firm investment (Q5[-4,-2]) were significantly higher than the share returns of portfolios with higher firm investment (Q1[-2,0]). This negative relationship between firm investment and share return was statistically significant at the 95% significance level.

The study found that there was a significant negative relationship between firm investment and subsequent share return on the optimised case. The null hypothesis ( $H_{20}$ ) was rejected.

### 5.3 I–R association with abnormal effects

The significance of the difference of the means in the characteristic variables of the Q1 and Q5 portfolios were tested, using paired sample t-tests with bootstrap, for all the four cases (see section 4.9.3). The characteristic variables tested were book-to-market ratio, market value, equity issuance, debt-to-market equity, and profitability. The difference in the selected characteristic variables between the Q1 and Q5 portfolios is analysed below.

The researcher reports on visual observations from the graphical representations in the figures below; and on the statistical results from the paired t-tests that analysed the difference in the Q1 and Q5 portfolios for the four cases analysed. The paired t-test results are shown in Table 5.2. A summary of results is shown in Table 5.3 .

**Table 5.2: Paired samples test difference of effects**

Paired samples test										
Effect	Pair		Paired differences					t-statistic	Degrees of freedom	Significance (2-tailed)
			Mean	Standard deviation	Standard error mean	95% confidence interval of the difference				
						Lower	Upper			
Book-to-market	Optimised case	Q1[-2,0] book-to-market ratio - Q5[-4,-2] book-to-market ratio	-0.155	0.137	0.015	-0.185	-0.125	-10.268	81	0.000
	Short horizon case	Q1[-2,0] book-to-market ratio - Q5[-2,0] book-to-market ratio	-0.219	0.204	0.022	-0.264	-0.174	-9.751	81	0.000
	Medium horizon case	Q1[-4,-2] book-to-market ratio - Q5[-4,-2] book-to-market ratio	-0.100	0.156	0.017	-0.134	-0.066	-5.825	81	0.000
	Long horizon case	Q1[-10,-3] book-to-market ratio - Q5[-10,-3] book-to-market ratio	-0.095	0.150	0.017	-0.129	-0.062	-5.753	81	0.000
Size	Optimised case	Q1[-2,0] market value - Q5[-4,-2] market value	581.022	4366.828	482.236	-378.476	1540.519	1.205	81	0.232
	Short horizon case	Q1[-2,0] market value - Q5[-2,0] market value	864.713	3816.136	421.422	26.216	1703.210	2.052	81	0.043
	Medium horizon case	Q1[-4,-2] market value - Q5[-4,-2] market value	1035.831	4471.783	493.826	53.273	2018.390	2.098	81	0.039
	Long horizon case	Q1[-10,-3] market value - Q5[-10,-3] market value	3107.184	5089.234	562.012	1988.956	4225.411	5.529	81	0.000

Paired samples test										
Effect	Pair		Paired differences					t-statistic	Degrees of freedom	Significance (2-tailed)
			Mean	Standard deviation	Standard error mean	95% confidence interval of the difference				
						Lower	Upper			
Equity issuance	Optimised case	Q1[-2,0] equity issuance - Q5[-4,-2] equity issuance	0.022	0.043	0.005	0.012	0.031	4.567	81	0.000
	Short horizon case	Q1[-2,0] equity issuance - Q5[-2,0] equity issuance	0.025	0.043	0.005	0.016	0.035	5.232	81	0.000
	Medium horizon case	Q1[-4,-2] equity issuance - Q5[-4,-2] equity issuance	0.006	0.023	0.003	0.001	0.011	2.290	81	0.025
	Long horizon case	Q1[-10,-3] equity issuance - Q5[-10,-3] equity issuance	0.002	0.019	0.002	-0.003	0.006	0.793	81	0.430
Debt-to-market equity	Optimised case	Q1[-2,0] debt-to-market equity ratio - Q5[-4,-2] debt-to-equity ratio	0.037	0.106	0.012	0.014	0.061	3.163	81	0.002
	Short horizon case	Q1[-2,0] debt-to-market equity ratio - Q5[-2,0] debt-to-equity ratio	0.000	0.140	0.016	-0.031	0.031	-0.003	81	0.998
	Medium horizon case	Q1[-4,-2] debt-to-market equity ratio - Q5[-4,-2] debt-to-equity ratio	0.046	0.111	0.012	0.022	0.071	3.791	81	0.000
	Long horizon case	Q1[-10,-3] debt-to-market equity ratio - Q5[-10,-3] debt-to-equity ratio	0.079	0.076	0.008	0.063	0.096	9.492	81	0.000

Paired samples test										
Effect	Pair		Paired differences					t-statistic	Degrees of freedom	Significance (2-tailed)
			Mean	Standard deviation	Standard error mean	95% confidence interval of the difference				
						Lower	Upper			
Profitability	Optimised case	Q1[-2,0] profitability - Q5[-4,-2] profitability	0.102	0.087	0.010	0.083	0.121	10.589	81	0.000
	Short horizon case	Q1[-2,0] profitability - Q5[-2,0] profitability	0.149	0.099	0.011	0.127	0.170	13.637	81	0.000
	Medium horizon case	Q1[-4,-2] profitability - Q5[-4,-2] profitability	0.055	0.081	0.009	0.037	0.073	6.149	81	0.000
	Long horizon case	Q1[-10,-3] profitability - Q5[-10,-3] profitability	0.007	0.061	0.007	-0.006	0.020	1.022	81	0.310

**Table 5.3: Results I–R association with abnormal effects**

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
Book-to-market	Optimised case	From Figure A.5, the book-to-market ratio trend for Q1[-2,0] was consistently below the book-to-market ratio trend Q5[-4,-2], indicating higher levels of investment (Q1[-2,0]) were associated with lower book-to-market ratios.	<p>The paired t-test (Table 5.2) shows that the book-to-market ratio for Q1[-2,0] was significantly lower than the book-to-market ratio for Q5[-4,-2], at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were significantly associated with a lower book-to-market ratio, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 significance level.</p>	The null hypothesis H3.1.1 <sub>0</sub> (optimised case) was rejected.
Book-to-market	Short horizon case	From Figure A.6, the book-to-market ratio for Q1[-2,0] was consistently below the book-to-market ratio for Q5[-2,0], indicating higher levels of	The paired t-test (Table 5.2) shows that the book-to-market ratio for Q1[-2,0] was significantly lower than the book-to-market ratio for Q5[-2,0], at the 0.01 significance level.	The null hypothesis H3.1.2 <sub>0</sub> (short horizon case) was rejected.

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
		investment (Q1[-2,0]) were associated with lower book-to-market ratios.	Based on these statistical tests, higher firm investment and lower share return were significantly associated with a lower book-to-market ratio, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 significance level.	
Book-to-market	Medium horizon case	From Figure A.7, the book-to-market ratio Q1[-4,-2] was below the book-to-market ratio for Q5[-4,-2], indicating higher levels of investment (Q1[-4,-2]) were associated with lower book-to-market ratios.	<p>The paired t-test (Table 5.2) shows that the book-to-market ratio for Q1[-4,-2] was significantly lower than the book-to-market ratio for Q5[-4,-2], at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were significantly associated with a lower book-to-market ratio, as compared to the lower firm investment and higher share return portfolio, with respect to</p>	The null hypothesis H3.1.3 <sub>0</sub> (medium horizon case) was rejected.

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
			these look-back periods, at the 0.01 significance level.	
Book-to-market	Long horizon case	From Figure A.8, the book-to-market ratio for Q1[-10,-3] was below the book-to-market ratio for Q5[-10,-3], indicating higher levels of investment (Q1[-10,-3]) were associated with lower book-to-market ratios.	<p>The paired t-test (Table 5.2) shows that the book-to-market ratio for Q1[-10,-3] was significantly lower than the book-to-market ratio for Q5[-10,-3], at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were significantly associated with a lower book-to-market ratio, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 significance level.</p>	The null hypothesis H3.1.4 <sub>0</sub> (long horizon case) was rejected.
Size	Optimised case	From Figure A.9, Q1[-2,0] crosses over Q5[-4,-2] a few times. The difference between the portfolios was not persistent. However, the trendline	The paired t-test (Table 5.2) shows that the market value for Q1[-2,0] was higher than the market value for Q5[-4,-2],	The null hypothesis H3.2.1 <sub>0</sub> (optimised case) was not rejected.

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
		for Q1[-2,0] is slightly higher than Q5[-4,-2], indicating higher levels of investment (Q1[-2,0]) were associated with lower market values.	<p>however the difference was not significant at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were not significantly associated with a lower market value, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 significance level.</p>	
Size	Short horizon case	From Figure A.10, Q1[-2,0] crosses over Q5[-2,0] a few times, and the difference between these portfolios is not persistent. However, the trendline for Q1[-2,0] is slightly higher Q5[-2,0], indicating higher levels of investment (Q1[-2,0]) were associated with higher market values.	<p>The paired t-test (Table 5.2) shows that the market value for Q1[-2,0] was higher than the market value for Q5[-2,0], however the difference was not significant at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were not significantly associated with a higher market value, as compared to the lower firm investment and higher share</p>	The null hypothesis H3.2.2 <sub>0</sub> (short horizon case) was not rejected.



Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
			return portfolio, with respect to these look-back periods, at the 0.01 significance level.	
Size	Medium horizon case	From Figure A.11, the market value for Q1[-4,-2] was above the market value for Q5[-4,-2], indicating higher levels of investment (Q1[-4,-2]) were associated with higher market values.	<p>The paired t-test (Table 5.2) shows that the market value for Q1[-4,-2] was higher than the market value for Q5[-4,-2], however the difference was not significant at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were not significantly associated with a higher market value, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 significance level.</p>	The null hypothesis H3.2.3 <sub>0</sub> (medium horizon case) was not rejected.
Size	Long horizon case	From Figure A.11, the market value for Q1[-10,-3] was above the market value for Q5[-10,-3], indicating higher	The paired t-test (Table 5.2) shows that the market value for Q1[-10,-3] was significantly above than the market	The null hypothesis H3.2.4 <sub>0</sub> (long horizon case) was rejected.

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
		levels of investment (Q1[-10,-3]) were associated with higher market values.	<p>value for Q5[-10,-3], at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were significantly associated with a lower market value, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 level.</p>	
Equity issuance	Optimised case	From Figure A.13, Q1[-2,0] was consistently above Q5[-4,-2], indicating higher levels of investment (Q1[-2,0]) were associated with higher equity issuances.	<p>The paired t-test (Table 5.2) shows that the equity issuance for Q1[-2,0] was significantly higher than the equity issuance for Q5[-4,-2], at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were significantly associated with a higher equity issuance, as compared to the lower firm investment and higher share return portfolio, with respect to</p>	The null hypothesis H3.3.1 <sub>0</sub> (optimised case) was rejected.

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
			these look-back periods, at the 0.01 significance level.	
Equity issuance	Short horizon case	From Figure A.14, Q1[-2,0] was consistently above Q5[-2,0], indicating higher levels of investment (Q1[-2,0]) were associated with higher equity issuances.	<p>The paired t-test (Table 5.2) shows that the equity issuance for Q1[-2,0] was significantly higher than the equity issuance for Q5[-2,0], at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were significantly associated with a higher equity issuance, as compared to the lower firm investment and higher share return portfolio, at the 0.01 significance level.</p>	The null hypothesis H3.3.2 <sub>0</sub> (short horizon case) was rejected.
Equity issuance	Medium horizon case	From Figure A.15, the equity issuance for Q1[-4,-2] was above Q5[-4,-2], indicating higher levels of investment (Q1[-4,-2]) were associated with higher equity issuance.	The paired t-test (Table 5.2) shows that the equity issuance for Q1[-4,-2] was not higher than the equity issuance for Q5[-4,-2], at the 0.01 significance level.	The null hypothesis H3.3.3 <sub>0</sub> (medium horizon case) was not rejected.

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
			Based on these statistical tests, higher firm investment and lower share return were not significantly associated with a lower equity issuance, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 significance level	
Equity issuance	Long horizon case	From Figure A.16, Q1[-10,-3] was above Q5[-10,-3], indicating higher levels of investment (Q1[-10,-3]) were associated with higher equity issuances.	<p>The paired t-test (Table 5.2) shows that the equity issuance for Q1[-10,-3] was not significantly higher than the equity issuance for Q5[-10,-3], at the 0.01 significance level.</p> <p>Based on these statistical tests, there was no difference between the portfolios with respect to equity issuance, with respect to these look-back periods, at the 0.01 significance level.</p>	The null hypothesis H3.3.4 <sub>o</sub> (long horizon case) was not rejected.

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
Debt-to-market equity	Optimised case	From Figure A.17, the debt-to-market ratio Q1[-2,0] was higher than Q5[-4,-2], indicating higher levels of investment (Q1[-2,0]) were associated with lower debt-to-market equity, however this difference was not persistent.	<p>The paired t-test (Table 5.2) shows that the debt-to-market equity for Q1[-2,0] was significantly higher than the debt-to-market equity for Q5[-4,-2], at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were significantly associated with a higher debt-to-market equity, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 level.</p>	The null hypothesis H3.4.1 <sub>o</sub> (optimised case) was rejected.
Debt-to-market equity	Short horizon case	From Figure A.18, the debt-to-market equity ratio Q1[-2,0] crosses over the debt-to-market ratio of Q5[-2,0]. The difference between the portfolios was not persistent.	The paired t-test (Table 5.2) shows that there was no significant difference in the debt-to-market equity for Q1[-2,0] as compared to the debt-to-market equity for Q5[-2,0], at the 0.01 significance level.	The null hypothesis H3.4.2 <sub>o</sub> (short horizon case) was not rejected.

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
			Based on these statistical tests, higher firm investment and lower share return were not significantly associated with a lower debt-to-market equity, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 significance level.	
Debt-to-market equity	Medium horizon case	From Figure A.19, the debt-to-market equity for Q1[-4,-2] was above the debt-to-market equity for Q5[-4,-2], indicating higher levels of investment (Q1[-4,-2]) were associated with higher debt-to-market equity.	The paired t-test (Table 5.2) shows that the debt-to-market equity for Q1[-4,-2] was significantly higher than the debt-to-market equity for Q5[-4,-2], at the 0.01 significance level. Based on these statistical tests, higher firm investment and lower share return were significantly associated with a lower debt-to-market equity, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 significance level.	The null hypothesis H3.4.3 <sub>0</sub> (medium horizon case) was rejected.

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
Debt-to-market equity	Long horizon case	From Figure A.20, the debt-to-market equity for Q1[-10,-3] was consistently above the debt-to-market equity for Q5[-10,-3], indicating higher levels of investment (Q1[-10,-3]) were associated with higher debt-to-market equity.	<p>The paired t-test (Table 5.2) shows that the debt-to-market equity for Q1[-10,-3] was significantly higher than the debt-to-market equity for Q5[-10,-3], at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were significantly associated with a higher debt-to-market equity, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 level.</p>	The null hypothesis H3.4.4 <sub>0</sub> (long horizon case) was rejected.
Profitability	Optimised case	From Figure A.21, the profitability for Q1[-2,0] was consistently higher than the profitability for Q5[-4,-2], indicating higher levels of investment (Q1[-2,0]) were associated with higher profitability.	The paired t-test (Table 5.2) shows that the profitability for Q1[-2,0] was significantly higher than the profitability for Q5[-4,-2], at the 0.01 significance level.	The null hypothesis H3.5.1 <sub>0</sub> (optimised case) was rejected.

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
			Based on these statistical tests, higher firm investment and lower share return were significantly associated with a higher profitability, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 significance level.	
Profitability	Short horizon case	From Figure A.22, the profitability for Q1[-2,0] was consistently above the profitability for Q5[-2,0], indicating higher levels of investment (Q1[-2,0]) were associated with a higher profitability.	<p>The paired t-test (Table 5.2) shows that the profitability for Q1[-2,0] was significantly higher than the profitability for Q5[-2,0], at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were significantly associated with a higher profitability, as compared to the lower firm investment and higher share return portfolio, with respect to these</p>	The null hypothesis H3.5.1 <sub>0</sub> (short horizon case) was rejected.



Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
			look-back periods, at the 0.01 significance level.	
Profitability	Medium horizon case	From Figure A.23, the profitability for Q1[-4,-2] was above the profitability for Q5[-4,-2], indicating higher levels of investment (Q1[-4,-2]) were associated with higher profitability.	<p>The paired t-test (Table 5.2) shows that the profitability for Q1[-4,-2] was significantly higher than the profitability for Q5[-4,-2], at the 0.01 significance level.</p> <p>Based on these statistical tests, higher firm investment and lower share return were significantly associated with a higher profitability, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 level.</p>	The null hypothesis H3.5.1 <sub>0</sub> (medium horizon case) was rejected.
Profitability	Long horizon case	From Figure A.24, there was no clear difference in profitability between Q1[-10,-3] and Q5[-10,-3].	The paired t-test (Table 5.2) shows that there was no difference in profitability between Q1[-10,-3] and Q5[-10,-3], at the 0.01 significance level.	The null hypothesis H3.5.1 <sub>0</sub> (long horizon case) was not rejected.

Effect	Case	Visual observation	Paired t-test	Results of the hypotheses tested
			Based on these statistical tests, higher firm investment and lower share return were not significantly associated with a higher profitability, as compared to the lower firm investment and higher share return portfolio, with respect to these look-back periods, at the 0.01 significance level.	

## 5.4 Summary of key results

The key results of the study are listed below.

In the South African developing market context of high-risk, low-turnover and high-volatility conditions –

- The I–R relationship was dependent on investment and lag periods. The I–R relationship was strongly negative with short investment and lag periods, and the I–R relationship became less negative as lag and investment periods increased in length of time.
- There was a significant negative relationship between firm investment and subsequent share return, with the optimal investment and lag periods.
- The I–R relationship was significantly associated with the book-to-market ratios for the short, medium and long horizon cases. The book-to-market ratios was lower for firms with lower investment and higher returns, as compared to firms with higher investment and lower returns, for the short, medium and long horizon cases.
- The I–R relationship was not significantly associated with size for the short and medium horizons. The I–R relationship was significantly associated with size for the long horizon. The market value was higher for firms with higher investment and lower returns, as compared to firms with lower investment and higher returns, for the long horizon case.
- The I–R relationship was significantly associated with equity issuance for the short horizon case. The equity issuance was higher for firms with higher investment and lower returns, as compared to firms with lower investment and higher returns, for the short horizon case. The I–R relationship was not significantly associated with equity issuance for the medium and long horizon cases.
- The I–R relationship was not significantly associated with debt-to-market equity for the short horizon cases. The I–R relationship was significantly associated with debt-to-market equity for the medium and long horizon cases. The debt-to-market equity was higher for firms with higher investment and lower returns, as compared to firms with lower investment and higher returns, for the medium and long horizon cases.
- The I–R relationship was significantly associated with profitability for the short and medium horizon cases. Investment was higher and returns were lower for firms with higher profitability, as compared to firms with lower profitability in the short and medium horizon cases. The I–R relationship was not significantly associated with profitability for the long horizon case.

## **Chapter 6: Discussion**

This chapter discusses insights from the study results and provides a critical analysis anchored on the IBAPT. The chapter builds on this theory by presenting the methodological and contextual distinctiveness of this study and discusses the implications of including the investment process variables of investment period and lag period in the theory. The impact of investment period and lag period on the strength and significance of the negative relationship between firm investment and share return is discussed. The impact of these investment process variables on the I–R association with abnormal effects of value-versus-growth, size, equity issuance, debt-to-equity, and profitability is then discussed in relation to the IBAPT.

### **6.1 Methodological differences**

Previous studies have employed the linear measure of firm investment (the change in net assets from the beginning of the measurement period to the end of the measurement period). However, the robustness of the results of the current study was confirmed using two different measures of firm investment. This research employed the traditional linear measure to measure firm investment as the change in net assets over the two points in time, as well as the Excel LOGEST function, which fits an exponential, best-fit, growth-rate curve, using the change in net assets for each interval (multiple points) within the measurement period. The linear measure uses just two data points over the period – the start and end points. The LOGEST measure fits a line to all the points over the period and uses the slope of the line. Fitting the LOGEST function has not been employed in earlier scholarship, but the current research found the LOGEST function to be reliable in analysing the 32-year data, with varying look-back periods. The negative I–R relationship was significant using both the linear and LOGEST measures.

The current study used time-series over a significant length of time (30 September 1987 to 31 March 2019) on developing market data. Previous studies – including Hou et al. (2015) employed cross-sectional regressions in developing the q-factor model. The IBAPT is based on cross-sectional analysis, developed under static conditions, and the investment CAPM model is a cross-sectional model. This study, by contrast, looked at the cumulative effect over a time-series period, in a dynamic and changing environment. The problem with cross-sectional analysis is that the analysis depends on the average results of the portfolios. However, the current study primarily employed time series analysis which tracks the consistency of the relative differences between the portfolios and the cumulative change in share return over time. This eliminated the problem of drawing erroneous conclusions inherent in merely looking at averages in cross-section between the different portfolios.

The current study examined the relationship between firm investment and subsequent share return, and studied the impact of investment process variables – investment period and lag period – on this relationship, something not examined in previous literature. The current study examined cases based on different investment and lag periods. It further explored the effects observed in literature which previously just employed a standard one-year lag. The portfolios were bootstrapped to determine whether the investment style is a significant factor, using firm and market variables from the real dataset and the style engine to construct the lower and upper limits of the bootstrap.

## **6.2 Contextual differences**

Titman et al. (2013) compared developed and developing markets in terms of efficiency. They generalised that the negative I–R will be significant in developed markets and weak in developing markets, due to relative inefficiencies of developing markets compared to developed markets. Zhang (2017) argues that the defence of efficient markets is not necessary, but rather that asset-pricing anomalies have not been convincingly explained by rational scientists, because the explanations depend on consumption-based asset-pricing theories. Zhang (2017) argues that equating anomalies to inefficient markets indicates a failure of the consumption-based asset-pricing theories in explaining asset-pricing anomalies. This has also given rise to behaviour-based explanations. Hou et al. (2015) show that 80 predominant anomalies reported in literature can be explained by the IBAPT. From the IBAPT perspective, Zhang (2017) argues that the q-factor model is not necessarily a risk-based model, and that there is no need to relate this to the efficiency of markets or the level of mispricing in the markets.

This current study was based on South African, developing market, data over a significant period of time. In spite of economic fluctuations – including notable economic crashes over the period (refer to Figure 2.1, Figure 2.2, and Figure 2.3 for the economic trends in South Africa over the period) – the investment style held over the period, which is consistent with the IBAPT. The negative I–R relationship was still significant in this context, in spite of the high-volatility, low-turnover and high-risks of the context.

## **6.3 Further enhancements to investment-based asset-pricing theory**

This study produced evidence that further confirms aspects of the IBAPT, as well as enhancing it. Over and above the methodological and contextual differences discussed above, the study extended the concept of firm investment in the IBAPT.

### **6.3.1 I–R relationship, investment and lag periods**

The current study found that effect of timing must also be taken into account in asset-pricing. The current research found that the I–R relationship is related to investment and lag periods, and that the pattern of I–R to investment and lag periods is similar with different measures of firm investment. Lower investment resulted in higher returns for the short horizon, consistent with the IBAPT. Higher investment resulted in lower returns in the short term, also consistent with the IBAPT. This negative relationship was significant, based on the optimal investment period and lag period. For zero to one-year lags (short-horizon), there was a negative I–R with both measures of firm investment. With higher lag periods, the I–R relationship was negative for shorter investment periods, but this negative relationship weakened over longer investment periods until, with long investment periods and long lags, the I–R relationship turned positive.

Firm investment was significantly associated with subsequent share return. However, the relationship depends on the length of the investment period and the lag period (see Figure 4.1 above for an illustration of the investment period, lag period and performance period, and see section 5.1 which demonstrate this dependency on the length of the periods). In the short term (the optimised case), the negative I–R relationship was significant in the South African context, across the firms on the JSE, in time series over the study period 31 December 1995 to 31 March 2019.

Characteristics changed as the investment period and lag period were increased. The I–R relationship to book-to-market ratio, profitability and equity issuance characteristics were significant for the short and medium horizon, and I–R relationship to debt-to-market equity was significant for the long horizon. There was no association between I–R and size for the short horizon, but market value was higher with larger investment as compared to lower investment for the long horizon. This is an enhancement of the IBAPT.

### **6.3.2 Significant negative I–R relationship**

The IBAPT is based on the investment decision process, which itself is based on the principle of optimal investment for firms. The optimal investment decision of firms is – keep investing until the costs of doing so rise to the level of the discounted investment benefits (Zhang, 2017); implying high cost of capital is associated with low NPV of new capital and low investment, and alternatively low cost of capital is associated with high NPV of new capital and high investment (Zhang, 2017). Share returns reflect the cost of capital, and as a result high share returns are associated with low investment, and low share returns are associated with high investment.

The findings of the current research demonstrate that firm investment is a significant factor for asset-pricing. These results are consistent with recent work in the United States, where the firm investment variable was incorporated into the new IBAPT. This is despite the South African context of high-risk, high-volatility and low-turnover, contrary to the generalisations by the rational scientists. The investment factor is a significant factor determining share return, consistent with Zhang (2017) and Hou et al. (2015), and there is a clear causal relationship between firm investment and subsequent share return (Zhang, 2017). Fama and French (2015) also incorporated, in parallel, firm investment as a key factor in their five-factor empirical asset-pricing model.

### **6.3.3 *I–R association with abnormal effects***

The I–R association with abnormal effects (value-versus-growth, size, equity issuance, debt-to-equity, and profitability) is discussed in this section. The impact of the investment process of investment and lag period variables on this association is then discussed in relation to the IBAPT.

#### **6.3.3.1 *I–R association with book-to-market ratio***

Consistent with the IBAPT (Hou et al., 2015; Zhang, 2017), the current study found that abnormal value-versus-growth effects is associated with I–R. The study found that I–R is significantly associated with book-to-market ratio (see section 5.3) for the short, medium and long horizons. The current research also found that (value) firms with higher book-to-market ratios have higher investment rates and therefore lower share returns – consistent with the IBAPT – compared to (growth) firms with lower book-to-market ratios with lower investment rates. According to the IBAPT, controlling for a few firm characteristics is sufficient to explain the cross-section of expected returns.

The value premium is also consistent with the negative I–R relationship in terms of the consumption-based marginal-q definition (see section 3.2.1). Investment increases in marginal-q, and consequently value firms invest less and earn higher returns, than growth that invest more and earn lower returns (Xing, 2008).

This finding is additionally consistent with the risk-based studies of Berk et al. (1999), Anderson and Garcia-Feijoo (2006), Xing (2008), and Trigeorgis and Lambertides (2014). Anderson and Garcia-Feijoo (2006) show that I–R is directly associated with book-to-market ratios. Berk et al. (1999) demonstrate this, from a real options perspective. Based on these scholars' (Berk et al., 1999) expected return equation (Equation 3.5), expected return is positively associated with the book-to-market ratio of the firm. The positive association of expected returns with the book-to-market ratio

leads to higher average share returns for firms with higher book-to-market ratios than for firms with lower book-to-market ratios.

Additional support is found in the three-factor model of Fama and French (1992, 1993), where expected share return is related to the book-to-market value of the firm, and higher share return is empirically found for value firms as compared to growth firms. Berk et al. (1999) argue that Fama and French's (1992, 1993) empirical observations – where share returns are related to size and the book-to-market ratio – are the result of the change in the risk profile of future cash flows, stemming from the current investment decisions of the firm. Fama and French (1992, 1993) suggest that risk related to shares is multidimensional and that size and book-to-market ratio serve as proxies for other dimensions of risk. They (Fama & French, 1992, 1993) further suggest that the book-to-market ratio could be related to the distress factor identified by Chan and Chen (1991), who argue that small firms could be more risky than large firms. They (Fama & French, 1992, 1993) suggest that the former could be marginal firms, sensitive to changes in the economy and with lower production efficiencies and higher financial leverage, and cash flow problems than the latter.

Although the book-to-market factor is a separate factor in the Fama and French (1992, 1993) three-factor model and the Fama and French (2015) five-factor model, it is not a separate factor in the investment CAPM. In this latter model the value premium is simply a different manifestation of the investment factor and is thus incorporated in the investment factor. Furthermore, according to Hou et al. (2015), the HML factor (of Fama and French (1992, 1993, 2015)) is unnecessary in the asset-pricing model. The HML factor is redundant according to Hou et al. (2015), and without the HML factor, the Fama and French (2015) five-factor model reduces to “a noisy version of the q-factor model” (Zhang., 2017, p.553). The investment premium is responsible for capturing the value-versus growth anomalies. The current study demonstrates that firm-level investment is directly correlated with these observations, and therefore the investment factor is an important factor to include in asset-pricing. This concurs with those IBAPT scholars (Cochrane, 1991; Hou et al., 2015; Liu et al., 2009; Zhang, 2017) who assert that the book-to-market ratio can be correlated with the investment premium, and who show that this can be mathematically derived from the investment CAPM equation (Zhang, 2017). This is an enhancement of the IBAPT.

#### **6.3.3.2 *I–R association with size***

The current research demonstrated that the association of I–R with size is not significant (for the short and medium horizons) in this market (see section 5.3). This is contrary to previous studies, such as by Berk et al. (1999), Fama and French (2015), and Anderson and Garcia-Feijoo (2006). Hou et al. (2015) found that the size factor plays a minimal role in the q-factor model. Zhang (2017)



similarly does not include size as a key factor in the investment CAPM. The current research found that the market value of the higher investment portfolio is significantly higher in the long horizon, consistent with the optimal investment principle. This is also consistent with the study of Berk et al. (1999) which found that an investment that has very low systematic risk looks attractive for the firm and making such investment leads to an increase in value. However, as a result, the average systematic risk of the firm's cash flows in subsequent periods is lowered, which leads to lower returns on average. This is an enhancement of the IBAPT.

#### **6.3.3.3 *I-R association with equity issuance***

The negative I-R relationship is also associated with 'abnormal' return observations apparent in previous studies (Li et al., 2009; Lyandres et al., 2008) due to financing activities, something confirmed by the current study. The current study shows that equity issuance is significantly associated with I-R in the short horizon. There was no difference in portfolios with respect to equity issuance in the medium to long horizons. Li et al. (2009) and Lyandres et al. (2008) found that the investment effect helps interpret the new issues puzzle. According to Li et al. (2009) and Lyandres et al. (2008), equity-issuing firms are disproportionately high investment firms, based on the flow of funds constraint (implying that the uses of funds must equate with the source of funds). Raising capital is required for higher investment, and distributing capital is related to lower investment (Li et al., 2009; Lyandres et al., 2008), based on the balance-sheet constraint of firms. This consequently results in the negative relationship between equity issuance and share returns. This was confirmed by the current study. This is an enhancement of the IBAPT.

#### **6.3.3.4 *I-R association with debt-to-market equity***

There was no association between I-R and debt-to-market ratio in the short horizon. In the medium to long horizon, there was a higher debt-to-market ratio with a higher investment portfolio as compared to the lower investment portfolio. This is consistent with the argument that investment funded through gearing reduces the cost of capital of the projects invested in. However, the current study found that equity issuance was significantly associated with investment for the short horizon. Kumar and Li (2016), however, propose, in terms of the risk-shifting view, that more levered firms have greater incentive to undertake projects with high idiosyncratic risk than less levered firms, because these risks are borne by lenders, benefiting shareholders from lower risk of equity and higher equity value. This will also result in a negative relationship between investment and subsequent share returns. This is confirmed in this study (Kumar & Li, 2016). This is an enhancement of the IBAPT.

### **6.3.3.5 *I-R association with profitability***

Based on the IBAPT, the investment effect should be stronger among firms with higher cash flows than among firms with lower cash flows (Zhang, 2017). The current study found that profitability was higher for the higher investment portfolios as compared to the lower investment portfolios in the short and medium horizons, however there was no difference between the higher investment and lower investment portfolios in the long horizon. This is consistent to the finding by Titman et al. (2004) that the negative I–R is effect is stronger among firms with higher cash flows than among firms with lower cash flows. This is an enhancement of the IBAPT.

## **6.4 Summary of key insights**

The IBAPT reports that firm investment is a significant predictor of share return, and that the I–R relationship is negative and significant. The current study extended the IBAPT by confirming that firm investment is a significant predictor of share return with optimised investment and lag periods, in the developing market context of high-risk, low-turnover and high-volatility; but that the relationship between firm investment and share return depends on the length of the investment period and the lag period. The I–R relationship is negative with short investment and lag periods but becomes less negative and more positive with an increase in investment period and lag period. In the short horizon, the I–R relationship is strongly associated with value-versus-growth effects, and effects associated with investment – equity issuance, debt-to-market equity, and profitability, however the association with these effects is dependent on the investment and lag periods. The I–R relationship is not associated with size in the short term; however, there is an association with market value in the long term. The investment factor is significantly correlated with abnormal effects in the market, and this further confirms that firm investment is a significant factor to be included in asset-pricing.

The context of the study was a developing market, a context dismissed by rational theorists as inefficient due to the determination of high arbitrage costs based on the conditions in the market. To date, this dismissal has relegated developing markets to study only by behavioural finance theorists who base their findings on investor sentiment, bias and mispricing. However, the findings of the current research restore developing markets to the area of rationality. The classification criteria for efficient markets need review. The current research findings are consistent with a rational IBAPT model that was tested in depth, using time-series data, over a significant period (1987-2019), using a methodology which ensured the robustness of the analysis. The author's findings and analysis does not totally preclude the impact of firm and investor behaviour on the observed phenomena, which could be the subject of future research.

## Chapter 7: Conclusion and recommendations

This chapter concludes the thesis with a review of the preceding chapters, a discussion of the importance and contribution of the study, and suggestions for future research. The study found that there is a significant negative relationship between firm investment and subsequent share return in the South African developing market context, and that this is dependent on investment period and lag period. The impact of timing in relation to IBAPT had not previously been studied. The study found that the negative relationship between firm investment and subsequent share return weakens as investment period and lag period are increased. This was tested and confirmed using different measures of firm investment – and one new, improved measure of firm investment. A matrix was formulated mapping the relationship between firm investment and share return in relation to firm investment period and lag period. The study also found that firm investment is associated with abnormal value-versus-growth effects, and investment effects – size, profitability, equity issuance, and debt-to-market – which is also dependent on the investment and lag periods. Thus, the current study confirmed and extended the investment-based asset-pricing theory in this context.

### 7.1 Research problem

At face value, firms with higher rates of investment should have higher subsequent shareholder returns than firms with lower rates of investment. However, multiple previous studies in developed markets have found a negative relationship between firm investment and subsequent share return (e.g. Alti & Tetlock, 2014; Anderson & Garcia-Feijóo, 2006; Berk et al., 1999; Cooper et al., 2008; Cooper & Priestley, 2011; Cordis & Kirby, 2017; George et al., 2018; Hou et al., 2015; Lam & Wei, 2011; Li & Zhang, 2010; Lin et al., 2018; Lipson et al., 2011; Mortal & Schill, 2015; Peters & Taylor, 2017; Song, 2016; Stambaugh & Yuan, 2017; Titman et al., 2004; Titman et al., 2013; Xing, 2008; Zhang, 2017).

Traditional consumption-based asset-pricing models fail to explain why share returns are lower for firms with a higher rate of investment as compared to firms with a lower rate of investment. The disagreement in the literature relates to whether this negative I–R relationship is the result of a risk-based rational explanation, or of the competing, behaviour-based explanation. Core to the behaviour-based explanation is the limits to arbitrage theory formulated by Shleifer and Vishny (1997). The behaviour-based explanation (see section 3.3) for the negative I–R relationship is that overinvestment and mispricing behaviours result in a negative I–R relationship that cannot be corrected, as explained by the limits to arbitrage theory (see section 3.3.1). The IBAPT offers a new perspective, based on economic and finance fundamentals, incorporating the perspective of the firm in asset-pricing. IBAPT relates share return to firm-level variables.

The IBAPT, initially conceptualised by Cochrane (1991), leveraging the analogous traditional consumption-based q-theory of investment, is core to a rational explanation for the negative I–R relationship, and the anchor of this thesis. IBAPT is nascent to asset-pricing, which has been dominated by the consumption-based models. IBAPT (see section 3.1) explains the negative I–R relationship by suggesting that firms optimise investment levels to maximise their market equity value, and invest such that their cost to capital equals market returns. This means that firms make higher investments on low cost of capital projects, which relates to lower share returns on the market. Previous consumption-based asset-pricing models, and other empirical models, have ignored the perspective of the firm in relating share return on the market, and for this reason these models have exhibited empirical failure.

The purpose of the current research was to examine the relationship between firm investment and shareholder return in a developing market context with conditions of high-volatility, low-turnover, and high-risk. IBAPT was initially conceptualised on US data, where a negative relationship between firm investment and share return was observed. Further, controversy exists over whether this phenomenon – based on efficient firms and markets and optimal investment decision-making – would be significant under developing market conditions. On one side of the debate, behavioural theorists would argue that the South African market has the ideal inefficient and irrational conditions for the anomaly to be significant. Rational theorists, on the other, would argue that the South African market is inefficient and therefore the negative relationship would be weak in this environment. Zhang (2017), at the same time, argues that this defence of efficient markets to put forward a rational explanation is not necessary.

Previous studies in the United States show a negative I–R relationship, which explains ‘anomalies’ in the market, according to the IBAPT. The IBAPT, however, explains the value-versus-growth, size, equity issuance and profitability effects. The q-factor model, developed on IBAPT, accounts for these ‘anomalies’ in the market. In the South African context, it was not previously known whether investment is a significant predictor of share return, whether investment could explain abnormal effects in this market, and whether the IBAPT holds in a context of high-volatility, low-turnover and high-risk. Nor had the impact of timing, length of investment period and lag period been studied before. The current research further extended the IBAPT, using different measures of firm investment, incorporating the dimensions of investment period and lag period, and using time-series methodology.

The research questions are listed below:

- Can firm investment, measured at firm level, be directly related to subsequent share return, measured at market level, in a developing market context of high-risk conditions, and high limits to arbitrage?
- Is the I–R relationship negative and significant, as conceptualised by IBAPT, in this market?
- What is the impact of the investment process (investment and lag periods), on the IBAPT, in terms of the I–R relationship?
- Does the I–R relationship account for abnormal effects observed in the market, which previously had been unexplained by traditional asset-pricing models?
- What is the impact of the investment process (investment and lag periods) on the IBAPT, in terms of the association between I–R and abnormal effects observed in the market?
- What is the impact of using different measures of firm investment on the significance of the I–R relationship?
- What is the impact of time-series, instead of cross-sectional analysis, on the IBAPT?

## **7.2 Methodology**

Part of this PhD study process was an article (Semnarayan et al., 2018) that was written and published. Some of the content formulated in producing the article is included in this thesis.

The buy-and-hold portfolio research strategy was used in this study. A data collection and data analysis application (termed the ‘style engine’) was built specifically for this study, using a Microsoft Access database, Microsoft Excel spreadsheet application, and Microsoft Visual Basic for Applications (VBA) software programming language. The style engine was built and tested to minimise bias and to ensure the validity, reliability and replicability of the results. Time-series firm financial and market data stretching from 1987 to 2019 across the main board of the JSE was analysed. Portfolios were grouped together into quintiles using two different measures of firm investment: one based on the linear ‘percentage net asset growth’ over the period, the other using the LOGEST function, which fits an exponential curve over all the net asset growth data over the period. The portfolios were recalculated and ranked every quarter and the value of each share was calculated daily from a base of 1.0, and the cumulative share return for each quintile was determined.

The relationship between firm investment and subsequent share return over different investment and lag periods was tested. Two portfolios, optimised in terms of investment and lag periods, were constructed: one with highest firm investment and the other with lowest firm investment. The significance of the negative I–R on the optimised case was tested. To test for statistical difference

between these two portfolios, a bootstrap distribution was constructed using the style engine, based on 100 random samples, since these series are autocorrelated and cumulative. The statistical robustness and utility of the style engine rest on using equally weighted portfolios to reduce the individual share noise in the data, and amassing the tiny daily differences in returns over the study period, which facilitates visualising and measuring the impact of the style strategy.

The association between the firm characteristic variables and the I–R relationship was then determined by comparing the constituents of the higher firm investment portfolio with those of the lower for different cases with different investment and lag periods. A short-horizon case (with a short investment period and short lag period), a medium-horizon-case (with a medium investment period and medium lag period), and a long-horizon case (with a long investment period and long lag period) were analysed to determine the difference in characteristics, and to determine the impact of investment and lag periods on the difference in characteristics.

### **7.3 Results**

The key results of the study are listed below.

In the South African developing market context of high-risk, low-turnover and high-volatility conditions –

- The I–R relationship was dependent on investment and lag periods. The I–R relationship was strongly negative with short investment and lag periods, and the I–R relationship became less negative as lag and investment periods increased in length of time.
- There was a significant negative relationship between firm investment and subsequent share return, with the optimal investment and lag periods.
- The I–R relationship was significantly associated with the book-to-market ratios for the short, medium and long horizon cases. The book-to-market ratios was lower for firms with lower investment and higher returns, as compared to firms with higher investment and lower returns, for the short, medium and long horizon cases.
- The I–R relationship was not significantly associated with size for the short and medium horizons. The I–R relationship was significantly associated with size for the long horizon. The market value was higher for firms with higher investment and lower returns, as compared to firms with lower investment and higher returns, for the long horizon case.
- The I–R relationship was significantly associated with equity issuance for the short horizon case. The equity issuance was higher for firms with higher investment and lower returns, as compared to firms with lower investment and higher returns, for the short horizon case. The

I–R relationship was not significantly associated with equity issuance for the medium and long horizon cases.

- The I–R relationship was not significantly associated with debt-to-market equity for the short horizon cases. The I–R relationship was significantly associated with debt-to-market equity for the medium and long horizon cases. The debt-to-market equity was higher for firms with higher investment and lower returns, as compared to firms with lower investment and higher returns, for the medium and long horizon cases.
- The I–R relationship was significantly associated with profitability for the short and medium horizon cases. Investment was higher and returns were lower for firms with higher profitability, as compared to firms with lower profitability in the short and medium horizon cases. The I–R relationship is not significantly associated with profitability for the long horizon case.

## **7.4 Discussion**

The negative relationship between firm investment and subsequent share return can be explained using the IBAPT (Cochrane, 1991; Hou et al., 2015; Liu et al., 2009; Zhang, 2017). The current study extended the IBAPT, which directly relates firm investment to share return, and confirms the negative I–R relationship, rationally. Based on this theory, higher firm investment is associated with lower cost of capital (equivalent to lower share returns), and vice versa. According to Cochrane (1991), investment return (at the firm level) is equal to share return (at the market level). Firm investment is ‘adjusted’ so that there are no arbitrage possibilities between share return (at market level) and investment return (at firm level), according to Cochrane (1991). Hou et al. (2015) developed the q-factor asset-pricing model based on the IBAPT, where firm investment is a key factor; and Fama and French (2015) also incorporated, in parallel, firm investment as a key factor in their five-factor empirical asset-pricing model.

Previous studies employed cross-sectional studies, used a standard one-year lag, and measured firm investment as a linear change in assets over the measurement period. The current time-series study shows that firm investment is related to share return, but this relationship depends on the investment and lag periods.

The current study confirmed that firm investment is significantly related to share return, with optimised investment and lag periods. The I–R relationship is negative with short investment and lag periods but becomes less negative and more positive with an increase in investment period and lag.

The q-factor model of Hou et al.'s (2015) is formulated on IBAPT, and shows how the firm investment factor, and expected profitability factor explains the 80 anomalies predominantly found and documented. The current study found that the I–R relationship is strongly associated with value-versus-growth effects, and effects associated with investment – equity issuance, debt-to-market equity, and profitability. However, the association with these effects is dependent on the investment and lag periods. This further extended the IBAPT.

The current study found that the I–R relationship is significantly associated with book-to-market ratio for the short, medium and long horizons. This finding is additionally consistent with the studies of Anderson and Garcia-Feijoo (2006), Berk et al. (1999), Xing (2008), Trigeorgis and Lambertides (2014). This is also consistent with the HML factor in the Fama and French (2015) five-factor model. The investment CAPM and Hou (2015) q-factor model does not include a separate value factor, as the investment factor captures this effect.

The current research found no significant association of I–R with size in the short and medium horizons, consistent with the IBAPT investment CAPM model. Although Hou et al. (2015), include size in their model, they include this is the model for evaluating mutual funds and assert that the incremental role of size is minimal. The current research found that the market value of the higher investment portfolio is significantly higher in the long horizon, which is consistent with the optimal investment principle.

The current study found that equity issuance is significantly associated with higher investment in the short horizon. There was no difference in portfolios with respect to equity issuance in the medium to long horizons. This is consistent with Li et al.'s (2009) and Lyandres et al.'s (2008) flow of funds constraint explanation, where capital raising is related to high investment and consequently low subsequent share returns, and capital distribution is related to low investment and consequently high subsequent share returns.

There was no association between I–R and debt-to-market ratio in the short horizon. In the medium and long horizon, there was a higher debt-to-market ratio with the higher investment portfolio as compared to the lower investment portfolio. This is consistent with the argument that gearing reduces the cost of capital of projects, and also shifts risk to the lenders for the benefit of shareholders, as explained by Kumar and Li (2016). Kumar and Li (2016) also argues that this explains the negative IVOL–return relationship on which the behavioural proponents base their mispricing argument.

Based on the IBAPT, the investment premium should be stronger among firms with higher cash flows (Zhang, 2017). The current study found that profitability is higher for the higher investment portfolios



as compared to the lower investment portfolios in the short and medium horizons. This also explains the observations of Titman et al. (2004) on US firms who instead interpreted this as overinvestment by firms, following periods of high cash flows. However, there is no difference in profitability between the higher investment and lower investment portfolios in the long horizon. These findings further extend the IBAPT.

The current study extended the IBAPT, which was formulated on developed market data, now in a developing market context characterised by high-volatility, high-risk and low-turnover conditions. This is contrary to previous literature that would have considered the context to have high arbitrage costs resulting in efficient firms and markets, inferring that the negative I–R relationship would be weak and insignificant in this context.

The research has provided answers to the research questions, summarised as follows –

- The research shows that firm investment, measured at firm level, can be directly related to subsequent share return measured at market level, in a developing market context of high-risk conditions, and high limits to arbitrage.
- The I–R relationship is negative and significant, as conceptualised by IBAPT, in this market.
- The strength and direction of the I–R relationship is dependent on investment and lag periods.
- The I–R relationship is associated with abnormal value-versus-growth effects, and investment effects – size, profitability, equity issuance, and debt-to-market observed in the market.
- The significance of the association between I–R to abnormal effects is dependent on the investment and lag periods.
- Different measures (linear and LOGEST) confirm that there is a significant negative I–R relationship.
- Previous studies used cross-sectional analysis methodology. This study used time-series. Results were consistent to the IBAPT, and further enhancements could be made to understand the impact of investment process time variables on the IBAPT.

## **7.5 Importance and contribution of the study**

The theoretical, methodological, practitioner and policy contributions of the current study are presented in this section. The current study extended the IBAPT by incorporating investment process variables into the theory. A style engine was built for the current study, which modelled developing market data, using a new measure of firm investment, over a long period of time. Furthermore,

bootstrap analysis, to test for significance of the results, was undertaken using the style engine on the database. The research confirmed that the extended IBAPT is useful for managers, investors and policymakers for both listed and unlisted assets, in developing and developed markets.

### **7.5.1 *The theoretical contribution***

The IBAPT is relatively newly developed, and the current study further extended this theory (see Hou et al., 2015; Zhang, 2017). Conceptually, expected share return could be related to fundamental firm-level variables, and this theory considers the firm side that has been ignored in extant asset-pricing literature. The current research found that this theory is associated with abnormal effects in the market, unexplained by the dominant consumption-based asset-pricing models. The theory provides a new perspective for understanding these constructs from the perspective of I–R. The current research extended the theory by examining the effect of investment process variables: varying the firm investment period, and the lag period.

The current study demonstrated that the I–R relationship depends on investment and lag periods, and that the negative relationship becomes weaker with an increase in lag or investment periods. The current study demonstrates that the I–R relationship is significant and negative, for optimised investment and lag periods. The current study additionally demonstrates that the relationship between firm investment and subsequent share return is associated with – and is associated with – abnormal value-to-growth ‘anomalies’ and investment effects in the market.

The IBAPT and rational risk-based models were developed in the United States on US data, but the current research examined the I–R relationship in a developing market context under high-risk, high-volatility and low-turnover conditions. The current research tested and developed the IBAPT as a strategy for explaining I–R research under developing market conditions characterised by significantly higher limits to arbitrage and a weaker institutional and economic environment than developed markets. Contrary to Titman et al. (2013), who argue that the negative I–R would not be significant in developing markets, this study found that the negative I–R is significant in the South African context. Previous risk literature argues that the negative I–R relationship would not be significant in a market such as South Africa, as they would characterise the market with high limits to arbitrage. This would be based on criteria of high-volatility and low-turnover. Instead, researchers would turn to the behavioural-based explanations premised on mispricing and overinvestment would hold in this environment. The current study found that these criteria to categorise efficient markets needs review. Although it would be easy to turn to a behavioural explanation in this context, the current study found that the IBAPT held in this context, suggesting that future studies should also take care when motivating theory based on broad untested assumptions of context. Such theory embodies, for example, arguments that rational theory works in the United States whereas

behavioural theory works in developing markets such as South Africa; or that characterise the United States as efficient but developing markets such as South Africa as inefficient, in spite of the strong financial constitution of the latter.

The approach employed by the current research permitted relating firm-level variables to share return, and the current research extended the concept of firm investment in the IBAPT. The results of this study thus contribute to the development of the investment-based asset-pricing literature, and suggest that future asset-pricing studies will need to pay careful attention to the investment period and lag period variables.

### ***7.5.2 The methodological contribution***

The current research was based on JSE share data and the associated financial data of the firms. The problem associated with doing this type of analysis in a developing market context is the lack of adequate data on shares and firms over a long period, and the high costs of setting up a buy-and-hold style analysis system (Rekenthaler et al., 2006). The researcher, however, did manage to solve this problem and undertake the study in this context. The current research employed a buy-and-hold portfolio research strategy over a significant span of JSE share and firm data (30 September 1987 to 31 March 2019). As noted above, this methodology has the power in its use of portfolios to minimise data noise and in its amassing of returns over time to magnify both results and facilitate a time-series examination of the timing and duration of effects (Rekenthaler et al., 2006). An in-depth study into the relationships between firm investment, risk and subsequent share returns was undertaken in a developing market context with data spanning 32 years.

The robustness of the results was confirmed using different measures of firm investment. Previous studies use the linear measure of firm investment (the linear change in net assets from the beginning of the measurement period to the end of the measurement period). The current research employed not only this traditional linear measure but also a new LOGEST Excel function that fits an exponential best-fit growth-rate curve using the change in net assets for each interval (multiple points) within the measurement period. Fitting the LOGEST function has not been used by previous studies. This study found that the LOGEST function was reliable in analysing the 32-year data, with varying look-back periods.

Earlier US studies are dominated by cross-sectional studies. This study in contrast to earlier work, employs a time series approach. Time-series make apparent the cumulative change in share return over time, while cross-sectional analysis increases the aggregation problem. The distinctiveness of the methodology is also discussed in section 6.1.

The current study examined the relationship between firm investment and subsequent share return, and examined the impact of investment process variables – investment period and lag period – on this relationship, something unexamined by previous literature. Previous studies use a standard one-year lag. Cases based on different investment periods and lag periods were further examined, that was not done previously.

The portfolios were bootstrapped to determine whether the investment style was significant, using real firm and market data, and constructing bootstrap lower and upper limits using the style engine. One hundred random cases were constructed on the dataset. The optimised case with the firm investment factor outperformed these 100 random cases, in terms of share return, confirming its significance. Previous studies would use standard statistical tests susceptible to autocorrelation problems.

### ***7.5.3 The practical contribution***

For managers and shareholders, optimising investments for the firm and shareholder return are fundamental and challenging. However traditional asset-pricing models embody limitations and have demonstrated empirical failures. Consumption-based asset-pricing models require listed market data and is impractical as a valuation tool for private firms. The investment-based asset-pricing model (such as the q-factor model and investment CAPM) based on IBAPT addresses these concerns, and is a better alternative, than the basic CAPM for example that is widely used. The investment-based asset-pricing model is a useful tool for managers and investors in determining pricing valuation for listed as well as other types of assets including private firms as documented in the literature. This thesis shows that investors could have earned a return premium of over 8% per annum, over the period 31 December 1995 and 31 March 2019, by taking optimal short and long positions on the firm investment factor.

### ***7.5.4 The policy contribution***

The foundations of the theory were aimed at informing monetary policy in the United States (Brainard & Tobin, 1968). Developing markets face increased challenges, due to the higher frictions in these smaller illiquid markets than in developed markets. These policy challenges include reducing risk and facilitating investment for economic growth. An improved understanding of the dynamics between firm investment and shareholder return will assist policymakers and regulators with these challenges. This thesis both demonstrates and confirms the relationship between firm level variables and market level variables from a rational perspective, based on fundamental economic principles.

The current research based on this context shows that rational assumptions hold in this context, and that higher investment is facilitated with lower cost of capital.

## **7.6 Recommendations for future research**

The recommendations for future research are listed below, based on the delimitations and limitations of the study discussed in section 4.12.

- The behavioural-based explanation has not been tested under these conditions. The author's findings and analysis does not totally preclude the impact of firm and investor behaviour on the phenomena. This could be the subject of future research into whether biases have any significant impact.
- This study looks at portfolios, and, as explained above, there is still some aggregation at this level, with all the risks that entails. Future studies could look at firms at the individual level.
- The methodology could be applied to other exchanges.
- Mining firms and financial services firms were excluded from this study; further research could be undertaken to incorporate mining firms and to examine the I–R relationship for different types of firms, since no distinction was made in the type of firm.
- Because South Africa is a developing market, the researcher found start-up issues with earlier data, and this suggests that future researcher could, with benefit, interrogate this data more closely.
- This scope of this study excluded the detailed study of the expected profitability factor of the investment CAPM. Future studies could, however, incorporate the investment and expected profitability factors in developing asset-based pricing models in this market.
- The effect of intangibles could be studied in more detail than the parameters of this research permitted.
- As indicated throughout this thesis, much of the literature around the IBAPT and associated constructs and questions, is new. The theory can be applied to other data, assets and markets, for example private firms.
- Future studies could incorporate real options methodology and risk.
- Extant finance literature largely studies markets and investors, ignoring the firm. This research has already demonstrated the utility of taking the firm perspective into account, and future research could undertake asset-pricing studies incorporating this perspective. The extended IBAPT developed in this study should be used. The LOGEST function should be used in measuring firm investment. All asset-pricing models should include the impact of the investment process variables of investment and lag period into their models.

## List of references

- Alti, A., & Tetlock, P. C. (2014). Biased beliefs, asset-prices, and investment: A structural approach. *Journal of Finance*, 69(1), 325–361. doi:10.1111/jofi.12089.
- Anderson, C. W., & Garcia-Feijóo, L. (2006). Empirical evidence on capital investment, growth options, and security returns. *Journal of Finance*, 61(1), 171–194. doi:10.1111/j.1540-6261.2006.00833.x.
- Bacharach, S. B. (1989). Organizational theories: Some criteria for evaluation. *The Academy of Management Review*, 14(4), 496–515.
- Baquero, G., ter Horst, J., Verbeek, M. (2005). Survival, look-ahead bias, and persistence in hedge fund performance. *Journal of Financial and Quantitative Analysis*, 40(3), 493–517.
- Bell, E. & Bryman, A. (2007). The ethics of management research: an exploratory content analysis. *British Journal of Management*, 18(1), 63–77.
- Berk, J. B., Green, R. C., & Naik, V. (1999). Optimal investment, growth options, and security returns. *Journal of Finance*, 54(5), 1553–1607.
- Bessler, W., Drobetz, W., & Grüninger, M. C. (2011). Information asymmetry and financing decisions. *International Review of Finance*, 11(1), 123–154.
- Brainard, W. C., & Tobin, J. (1968). Pitfalls in financial model-building. *American Economic Review*, 58, 99–122.
- Breeden, D.T. (1979). An intertemporal asset-pricing model with stochastic consumption and investment opportunities. *Journal of Financial Economics*, 7, 265–296.
- Bryman, A. (1984). The debate about quantitative and qualitative research: A question of method or epistemology? *The British Journal of Sociology*, 35(1), 75–92.
- Cao, C., Simin, T., & Zhao J. (2008). Can growth options explain the trend in idiosyncratic risk? *Review of Financial Studies*, 21(6), 2599–2633.
- Chan, K. C., & Chen, N. (1991). Structural and return characteristics of small and large firms. *Journal of Finance*, 46(4), 1467–1484.

- Chen, N., Roll, R., & Ross, S.A. (1986). Economic forces and the stock market. *Journal of Business*, 59(3), 383–403.
- Cochrane, J. H. (1991). Production-based asset-pricing and the link between share returns and economic fluctuations. *Journal of Finance*, 46(1), 209–237.
- Cochrane, J. H. (1996). A cross-sectional test of an investment-based asset-pricing model. *Journal of Political Economy*, 104, 572–621.
- Cooper, M. J., Gulen, H., & Schill, M. J. (2008). Asset growth and the cross-section of share returns. *Journal of Finance*, 63(4), 1609–1651. doi:10.1111/j.1540-6261.2008.01370.x.
- Cordis, A.S., & Kirby, C. (2017). Capital expenditures and firm performance: evidence from a cross-sectional analysis of stock returns. *Accounting & Finance*, 57, 1019–1042.
- Cooper, I., & Priestley, R. (2011). Real investment and risk dynamics. *Journal of Financial Economics*, 101, 182–205.
- Cooper, I. & Priestley, R. (2016). The expected returns and valuations of private and public firms. *Journal of Financial Economics*, 120, 41–57.
- Damodaran, A. (2013). Valuing Financial Services Firms. *Journal of Financial Perspectives*, 1(1), 1–16.
- Elton, E.J., Gruber, M.J., & Christopher R. Blake, C.R. (1996). Survivorship bias and mutual fund performance. *The Review of Financial Studies*, 9(4), 1097–1120.
- Evatt, G. W., Johnson, P. V., Duck, P. W., Howell, S. D. (2010). The Measurement and Inclusion of a Stochastic Ore-Grade Uncertainty in Mine Valuations Using PDEs. *International Journal of Applied Mathematics*, 40(4). 282–288.
- Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *Journal of Finance*, 25(2), 383–417.
- Fama, E. F., & French, K. R. (1992). The cross-section of expected share returns. *Journal of Finance*, 47(2), 427–465.

- Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on shares and bonds. *Journal on Financial Economics*, 33, 3–56.
- Fama, E. F., & French, K. R. (2004). The capital asset-pricing model: theory and evidence. *Journal on Economic Perspectives*, 18, 25–46.
- Fama, E. F., & French, K. R. (2008). Dissecting anomalies. *Journal of Finance*, 63(4), 1653–1678.
- Fama, E. F., & French, K. R. (2012a). Size, value, and momentum in international share returns. *Journal of Financial Economics*, 105, 457–472.
- Fama, E. F., & French, K. R. (2012b). Testing trade-off and pecking order predictions about dividends and debt. *The Review of Financial Studies*, 15, 1–33.
- Fama, E.F, & French, K.R. (2015). A five-factor asset-pricing model. *Journal of Financial Economics*, 116, 1–22.
- Fama, E. F., & French, K. R. (2016). Dissecting anomalies with a five-factor model. *The Review of Financial Studies*, 29, 69–103.
- Fama, E.F., & French, K.R. (2017). International tests of a five-factor asset-pricing model. *Journal of Financial Economics*, 123, 441-463.
- Financial Times. (2017). *South Africa*. Retrieved from [https://www.ft.com/topics/places/South\\_Africa](https://www.ft.com/topics/places/South_Africa).
- George, T.J., Hwang, C., & Li, Y. (2018). The 52-week high, q-theory, and the cross section of stock returns. *Journal of Financial Economics*, 128, 148–163.
- Harper, M. (2017). The role of institutional investors in promoting long-term value creation: A South African perspective. *African Review of Economics and Finance*, 9(1), 272–291.
- Hassani, H. (2010). The effect of noise reduction in measuring the linear and nonlinear dependency of financial markets. *Nonlinear Analysis: Real World Applications* (11)1, 1468–1218.
- Haynes, K. T., Hitt, M. A., & Campbell, J. T. (2015). The dark side of leadership: Towards a mid-range theory of hubris and greed in entrepreneurial contexts. *Journal of Management Studies*, 52(4), 479–505. doi:10.1111/joms.12127.



- Hill, M.R., (1984). Epistemology, axiology, and ideology in sociology. *Social Thought and Research*. 9(2), 59–77.
- Hou, K., Xue, C., & Zhang L. (2015). Digesting Anomalies: An Investment Approach. *Review of Financial Studies*, 28, 650–705.
- Iress. (2018). Research domain. Retrieved from <http://researchdomain.iress.co.za.uplib.idm.oclc.org/Default.aspx>.
- Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, 3(4), 305–360.
- Jeong, J., & Chung, S. (2001). Bootstrap tests for autocorrelation. *Computation Statistics & Data Analysis*. 38(1), 49–69.
- Kruger, P., Landier, A., & Thesmar, D. (2015). The WACC fallacy: The real effects of using a unique discount rate. *The Journal of Finance*, 70(3), 1253–1285.
- Kumar, P., & Li, D. (2016). Capital investment, innovative capacity, and share returns. *Journal of Finance*, 71(5), 2059–2094.
- La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (2006). What works in securities laws? *Journal of Finance*, 61(1), 1–32.
- Lakonishok, J., Shleifer, A., & Vishny, R. (1994). Abnormal investment, extrapolation, and risk. *Journal of Finance*, 49(5), 1541–1578.
- Lam, F.Y.E.C., & Wei, K.C.J. (2011). Limits-to-arbitrage, investment frictions, and the asset growth anomaly. *Journal of Financial Economics*, 102, 127–149.
- Lasfer, M.A. (1997). Scrip dividends: the management's view. *European Financial Management*, 3(2), 237–249.
- Li, X., Becker, Y., & Rosenfeld, D. (2012). Asset growth and future stock returns: international evidence. *Financial Analysts Journal*, 68(3), 51–62.
- Li, E. X. N., Livdan, D., & Zhang, L. (2009). Anomalies. *Review of Financial Studies*, 22, 4301–4334.

- Li, X., & Sullivan, R.N. (2011). The limits to arbitrage revisited: the accrual and asset growth anomalies. *Financial Analysts Journal*, 67(4), 50–66.
- Li, D., & Zhang, L. (2010). Does q-theory with investment frictions explain anomalies in the cross-section of returns? *Journal of Financial Economics*, 98, 297–314.
- Lin, W., Li, A., & Yuan, X. (2018). Effects of growth options on the post-earnings announcement drift. *Journal of Accounting and Finance*, 18(4), 101–113.
- Lintner, J. (1965). The valuation of risk assets and the selection of risky investments in share portfolios and capital budgets. *The Review of Economics and Statistics*, 47(1), 13–37.
- Lipson, M. L., Mortal, S., & Schill, M. J. (2011). On the scope and drivers of the asset growth effect. *Journal of Financial and Quantitative Analysis*, 46(6), 1651–1682.
- Liu, L. X., Whited, T. M., & Zhang, L. (2009). Investment-based expected return. *Journal of Political Economy*, 117, 1105–1139.
- Lucas, R. (1978). Asset prices in an exchange economy. *Econometrica*, 46(6), 1429–1445.
- Lyandres, E., Sun, L., & Zhang, L. (2008). The new issues puzzle: Testing the investment-based explanation. *Review of Financial Studies*, 21(6), 2825–2855.
- Marketline. (2017). South Africa in-depth PESTEL insights. Retrieved from <https://store.marketline.com/report/ml00002-025--south-africa-in-depth-pestle-insights>.
- McCallum, J. S. (1992). Using net present value in capital budgeting. *Business Quarterly*, 57(1), 66–71.
- Merton, R.C. (1973). Theory of rational option pricing. *The Bell Journal of Economics and Management Science*, 4(1), 141–183.
- Microsoft. (2019). LOGEST function. Retrieved from <https://support.office.com/en-us/article/logest-function-f27462d8-3657-4030-866b-a272c1d18b4b>.
- Miller, M. & Modigliani, F. (1961). Dividend policy, growth, and the valuation of shares. *Journal of Business*, 34(4), 411–433.

- Modigliani, F. & Miller, M.H. (1958). The cost of capital, corporation finance and the theory of investment. *The American Economic Review*, 48(3), 261–297.
- Mortal, S. & Schill, M.J. (2015). The post-acquisition returns of stock deals: evidence of the pervasiveness of the asset growth effect. *Journal of financial and quantitative analysis*, 50(3), 477–507.
- Mossin, J. (1966). Equilibrium in a capital asset market. *Econometrica*, 34(4), 768–783.
- Muller, C., & Ward, M. (2013). Style-based effects on the Johannesburg Stock Exchange: A graphical time-series approach. *Investment Analysts Journal*, 77, 1–16.
- Myers, S. (1977). Determinants of corporate borrowing. *Journal of Financial Economics*, 5, 147–175.
- Myers, S. C., & Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics*, 13, 187–221.
- Peters, R. H. & Taylor, L.A. (2017). Intangible capital and the investment-q relation. *Journal of Financial Economics*, 123, 251–272.
- Picone, P. M., Dagnino, G. B., & Minà, A. (2014). The origin of failure: A multidisciplinary appraisal of the hubris hypothesis and proposed research agenda. *Academy of Management Perspectives*, 28(4), 447–468. doi:10.5465/amp.2012.0177.
- Rehman, F., Kamal, Y., & Amin, S.U. (2017). The relationship between idiosyncratic, stock market volatility and excess stock returns. *Public Finance Quarterly*, 3, 311–325.
- Rekenthaler, J., Gambera, M., & Charlson, J. (2006). Estimating portfolio style in US equity funds: A comparative study of portfolio-based fundamental style analysis and returns-based style analysis. *Journal of Investing*, 15(3), 25–33.
- Rubinstein, M. (1976). The valuation of uncertain income streams and the pricing of options. *Bell Journal of Economics*, 7(2), 407–425.
- Rozeff, M.S. (1984). Dividend yields are equity risk premiums. *Journal of Portfolio Management*, 11(1), 68–75.

- Semnarayan, P., Ward, M., & Muller, C. (2018). The investment return puzzle on the Johannesburg Stock Exchange. *Investment Analysts Journal*, DOI: 10.1080/10293523.2018.1497127.
- Sharpe, W. F. (1964). Capital asset-prices: A theory of market equilibrium under conditions of risk. *Journal of Finance*, 19(3), 425–442.
- Sharpe, W. F., & Alexander, G. J. (1990). *Investments* (4th ed.). Englewood Cliffs, NJ: Prentice Hall.
- Shleifer, A., & Vishny, R. (1997). The limits of arbitrage. *Journal of Finance*, 52(1), 35–55.
- Song, Z. (2016). Asset growth and idiosyncratic return volatility. *Review of Finance*, 20(3), 1235–1258.
- South African Reserve Bank. (2018). *Prime overdraft rate*. Retrieved from <https://www.resbank.co.za/Research/Statistics/Pages/OnlineDownloadFacility.aspx>.
- Stambaugh, R.F., & Yuan, Y. (2017). Mispricing factors. *The Review of Financial Studies*, 30(4), 1270–1315.
- Statistics South Africa. (2018). *P0441 – Gross Domestic Product (GDP)*. Retrieved from [http://www.statssa.gov.za/?page\\_id=1854 &PPN=P0441](http://www.statssa.gov.za/?page_id=1854 &PPN=P0441).
- The World Bank. (2017). *World Bank in South Africa*. Retrieved from <http://www.worldbank.org/en/country/southafrica/overview>.
- The World Bank. (2018). *World development indicators*. Retrieved from <http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators#>.
- Titman, S., Wei, K. C. J., & Xie, F. (2004). Capital investments and share returns. *Journal of Financial & Quantitative Analysis*, 39(4), 677–700.
- Titman, S., Wei, K. C. J., & Xie, F. (2013). Market development and the asset growth effect: International evidence. *Journal of Financial & Quantitative Analysis*, 48(5), 1405–1432. doi:10.1017/S0022109013000495.
- Tobin, J. (1969). A general equilibrium approach to monetary theory. *Journal of Money, Credit and Banking*, 1, 15–29.

- Trigeorgis, L., & Lambertides, N. (2014). The role of growth options in explaining stock returns. *Journal of Financial & Quantitative Analysis*, 49(5), 749–771. doi:10.1017/S0022109014000118.
- Treynor, J. L. (1962). *Toward a theory of market value of risky assets* (Unpublished manuscript).
- Ward, M., & Muller, C. (2012). Empirical testing of the CAPM on the JSE. *Investment Analysts Journal*, 41(76), 1–12.
- World Economic Forum. (2017). The Global Competitiveness Report 2017–2018. Retrieved from <http://www3.weforum.org/docs/GCR2017-2018/05FullReport/TheGlobalCompetitivenessReport2017%E2%80%932018.pdf>.
- Xing, Y. (2008). Interpreting the value effect through the q-theory: An empirical investigation. *Review of Financial Studies*, 21, 1767–1795.
- Zhang, L. (2005). The value premium. *Journal of Finance*, 60(1), 67–104.
- Zhang, L. (2017). The investment CAPM. *European Financial Management*, 23(4), 545–603.

## Appendices

### Appendix A: Results modelled on linear measure of firm investment

#### A.1. *I-R relationship, investment and lag periods*

Figure A.1 shows the annualised share returns for the quintile with the highest investment in capital for varying firm investment, lag and performance periods. The data was analysed from 31 December 1988 to 31 December 2016.

Share returns for highest capital investment (linear measure)											
Capex end year											
Capex start year		-9	-8	-7	-6	-5	-4	-3	-2	-1	0
	-1	x	x	x	x	x	x	x	x	x	13.59%
	-2	x	x	x	x	x	x	x	x	12.25%	11.09%
	-3	x	x	x	x	x	x	x	13.19%	13.46%	12.58%
	-4	x	x	x	x	x	x	13.39%	13.86%	14.46%	13.30%
	-5	x	x	x	x	x	18.73%	17.50%	17.17%	15.79%	15.27%
	-6	x	x	x	x	18.00%	18.58%	18.21%	18.07%	19.69%	16.64%
	-7	x	x	x	13.36%	17.03%	19.51%	19.19%	19.60%	18.76%	18.05%
	-8	x	x	17.98%	16.49%	18.21%	20.96%	21.42%	20.78%	18.46%	16.70%
	-9	x	19.14%	21.79%	18.41%	18.81%	20.62%	22.00%	21.73%	18.49%	16.59%
	-10	21.71%	23.24%	22.42%	20.62%	20.41%	21.05%	22.82%	22.28%	20.21%	18.85%

**Figure A.1: Share returns for the highest firm investment quintile (linear measure of firm investment)**

From Figure A.1, returns were lower (red) for firms that had invested in capital in more recent years than for firms that had invested in capital in the earlier years (green). For the quintile with the highest

investment in capital, share returns would have been best (green) if the investments were made starting 9 or 10 years ago, with a lag of about 2 years. For the quintile with the highest investment in capital, share returns would have been worst (red) if the investments were made over the last 4 years. The worst (lowest) result from Figure A.1 was 11.09% per annum. This was for firms with a [-2,0] look-back t period (i.e. firms that commenced with firm investment two years before, with a firm investment period of two years, and no lag). Q1 was constructed later using this optimised [-2,0] look-back period. The highest result from Figure A.1 was 23.24% per annum, which was for firms with a [-10,-8] look-back period (i.e. firms that commenced with firm investment 10 years before, with a firm investment period of 2 years, and an 8-year lag).

Share returns for lowest capital investment (linear measure)										
Capex end year										
Capex start year	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
	x	x	x	x	x	x	x	x	x	22.76%
	x	x	x	x	x	x	x	x	21.28%	20.96%
	x	x	x	x	x	x	x	22.35%	22.07%	21.90%
	x	x	x	x	x	x	19.44%	20.56%	24.03%	24.30%
	x	x	x	x	x	13.47%	18.50%	21.44%	23.32%	23.21%
	x	x	x	x	14.62%	12.80%	15.58%	18.39%	21.21%	22.65%
	x	x	x	20.44%	18.62%	15.99%	16.35%	19.51%	21.17%	22.25%
	x	x	16.75%	20.38%	18.45%	18.08%	17.60%	19.17%	20.02%	20.91%
	x	17.26%	17.49%	19.40%	18.70%	18.16%	17.84%	18.53%	20.18%	21.03%
	15.50%	15.33%	17.32%	20.04%	18.96%	18.53%	17.79%	19.80%	20.58%	20.90%

**Figure A.2: Share returns for the lowest firm investment quintile (linear measure of firm investment)**

From Figure A.2, returns were higher (green) for firms, which invested the least in recent periods, particularly the last 3 years, than for firms that invested the least earlier than this. The highest result

from Figure A.2 is 24.3% per annum. This was for firms with a [-4,0] look-back period (firms that commenced capex 4 years previously, with a capex period of 4 years, and no lag). Q5 was constructed later using this [-4,0] look-back period. The lowest result from this figure is 12.8% per annum, which represents a [-6,-4] look-back period (firms that commenced with capex 6 years before, with a capex period of 2 years, and a lag period of 4 years prior to the return measurement date) from Figure A.2.

Difference of share returns (lowest capital investment minus highest capital investment) (linear measure)											
Capex end year											
Capex start year		-9	-8	-7	-6	-5	-4	-3	-2	-1	0
	-1	x	x	x	x	x	x	x	x	x	9.17%
	-2	x	x	x	x	x	x	x	x	9.03%	9.86%
	-3	x	x	x	x	x	x	x	9.16%	8.61%	9.32%
	-4	x	x	x	x	x	x	6.05%	6.69%	9.57%	11.00%
	-5	x	x	x	x	x	-5.26%	1.00%	4.27%	7.53%	7.94%
	-6	x	x	x	x	-3.37%	-5.78%	-2.63%	0.32%	1.52%	6.00%
	-7	x	x	x	7.08%	1.58%	-3.52%	-2.84%	-0.09%	2.41%	4.19%
	-8	x	x	-1.24%	3.89%	0.24%	-2.89%	-3.83%	-1.60%	1.55%	4.21%
	-9	x	-1.88%	-4.30%	0.99%	-0.11%	-2.46%	-4.16%	-3.21%	1.69%	4.44%
	-10	-6.21%	-7.91%	-5.10%	-0.58%	-1.45%	-2.53%	-5.03%	-2.49%	0.37%	2.05%

**Figure A.3: Difference of share returns between the lowest firm investment quintile and the highest firm investment quintile (linear measure of firm investment)**

Figure A.3 shows the differences in share return between the lowest and highest firm investment portfolios. From Figure A.3, it is clear that the difference between the cumulative returns between high firm investment and low firm investment portfolios depends on the firm investment periods and lag periods. For shorter firm investment periods and shorter lag periods, returns were higher for the

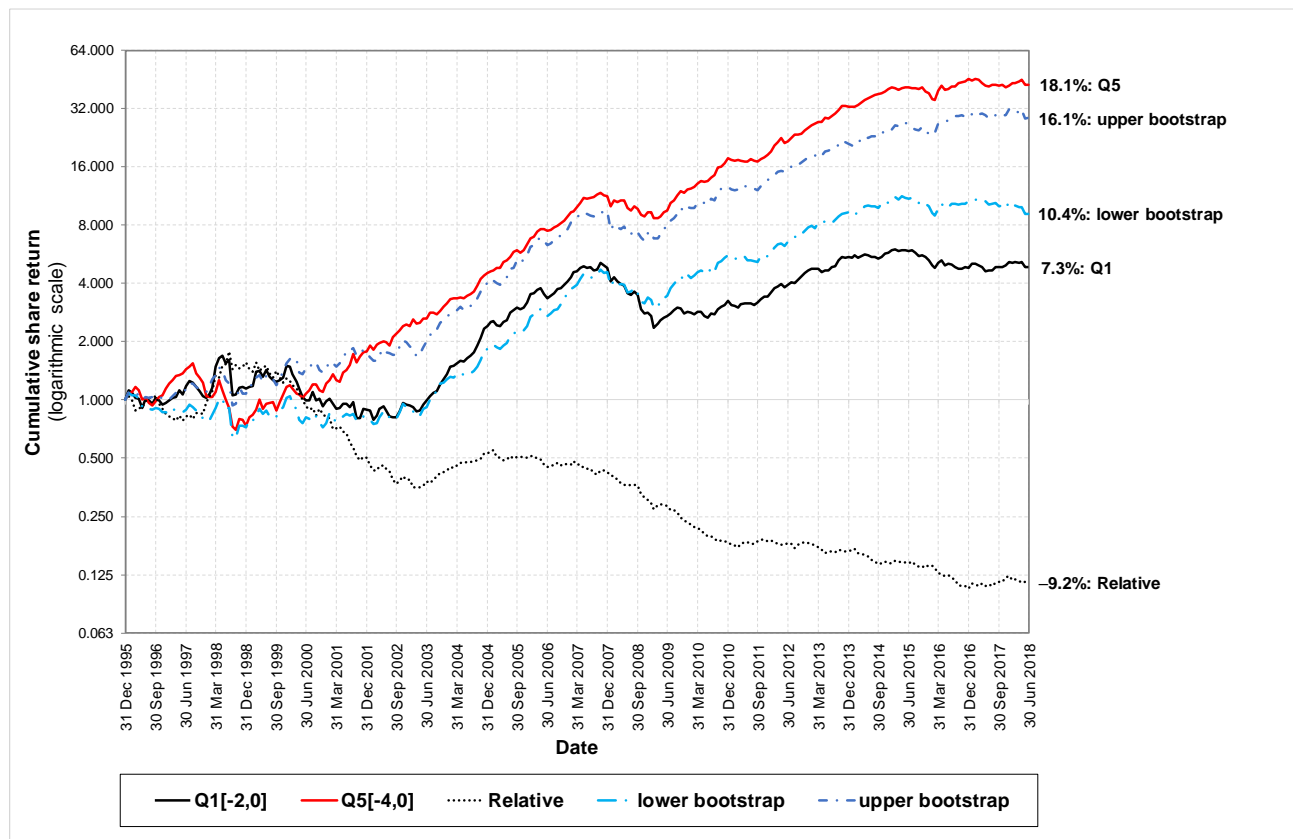


portfolio with lower firm investment. For longer firm investment periods and longer lag periods, returns were higher for the portfolio with higher firm investment. The relationship changed over time.

## A.2. Significant negative I-R relationship

The 'optimised' case for the linear measure of firm investment was derived from Figure A.1 and Figure A.2. The cumulative share return of Q1[-2,0] was the lowest in Figure A.1 at 11.09%, and the cumulative share return of Q5[-4,0] was the highest in Figure A.2 at 24.30%. For the linear measure of firm investment, the significance of the difference in share returns between Q1[-2,0] and Q5[-4,0] was determined.

Figure A.4 shows the returns of Q1 (highest firm investment portfolio with [-2,0] look-back period) and Q5 (lowest firm investment portfolio with [-4,0] look-back period), modelled on the linear measure of firm investment.



**Figure A.4: High-investment Q1[-2,0] and low-investment Q5[-4,0] portfolios with confidence limits (linear measure of firm investment)**

The quintile with companies investing the least (Q5) shows an 18.1% per annum cumulative return over the period December 1995 to June 2018. Investing in firms that had the lowest capex over the

previous 4 years gave the highest returns. The quintile with companies investing the most (Q1) shows a 7.3% per annum cumulative return over the period December 1995 to June 2018. Investing in firms that had the highest capex over the previous 2 years gave the lowest returns.

The price relative 'Relative' represents the ratio of Q1 to Q5 over the period. The price relative oscillates around 1.0 in the early start-up years between 31 December 1995 and 31 December 1999. The price relative declines between 31 December 1999 and 31 December 2002. Thereafter, the price relative increases between 31 December 2002 and 31 December 2004. The decline in the price relative was continuous and persistent between 31 December 2004 and 30 June 2018. This culminated in a relative difference of 9.2% between these two portfolios over the period 31 December 1995 and 30 June 2018. A long or short position would yield 9.2% per annum over the period, from these results. The investor could take a long position on the portfolio with the lowest firm investment (Q5), and at the same time take a short position on the portfolio with the highest firm investment (Q1), in this case. This option strategy over these two portfolios would yield an annual return premium of 9.2% over the period. If an investor held firms in the Q5 portfolio, and at the same time sold firms in the Q1 portfolio, the investor would have achieved a 9.2% premium over this period, on aggregate, based on the relative difference in the cumulative share returns of these portfolios.

The significance of the difference in share return between these two portfolios, Q1 and Q5, was then determined – the one with highest firm investment and the other with lowest firm investment. Figure A.4 shows the bootstrap results for Q1 and Q5 ('upper bootstrap' and 'lower bootstrap'). The 5<sup>th</sup> percentile return (upper bootstrap) was at 16.1% and the 95<sup>th</sup> percentile return (lower bootstrap) was at 10.4 percent. Q5 was significantly higher than upper bootstrap at 18.1% per annum cumulative return over the period, and Q1 was significantly lower than lower bootstrap at 7.3% per annum cumulative return over the period showing both these to be statistically significant.

A paired sample t-test using bootstrap for autocorrelation was also performed. The difference between Q1 and Q5 was significant, as shown in Table A.1.

**Table A.1: Paired samples test difference between Q1[-2,0] and Q5[-4,0]**

Paired samples test								
Pair	Paired differences					t- statistic	Degrees of freedom	Significa nce (2- tailed)
	Mean	Standard deviation	Standard error mean	95% confidence interval of the difference				
				Lower	Upper			
Q1[-2,0] - Q5[-4,0]	-11.468	13.557	0.824	-13.090	-9.847	-13.925	270	0.000

It could be concluded that the share returns of portfolios with lower firm investment were significantly higher than the share returns of portfolios with higher firm investment. This negative relationship between firm investment and share return was statistically significant at the 0.01 significance level.

## Appendix B: Visual representations of I-R association with abnormal effects

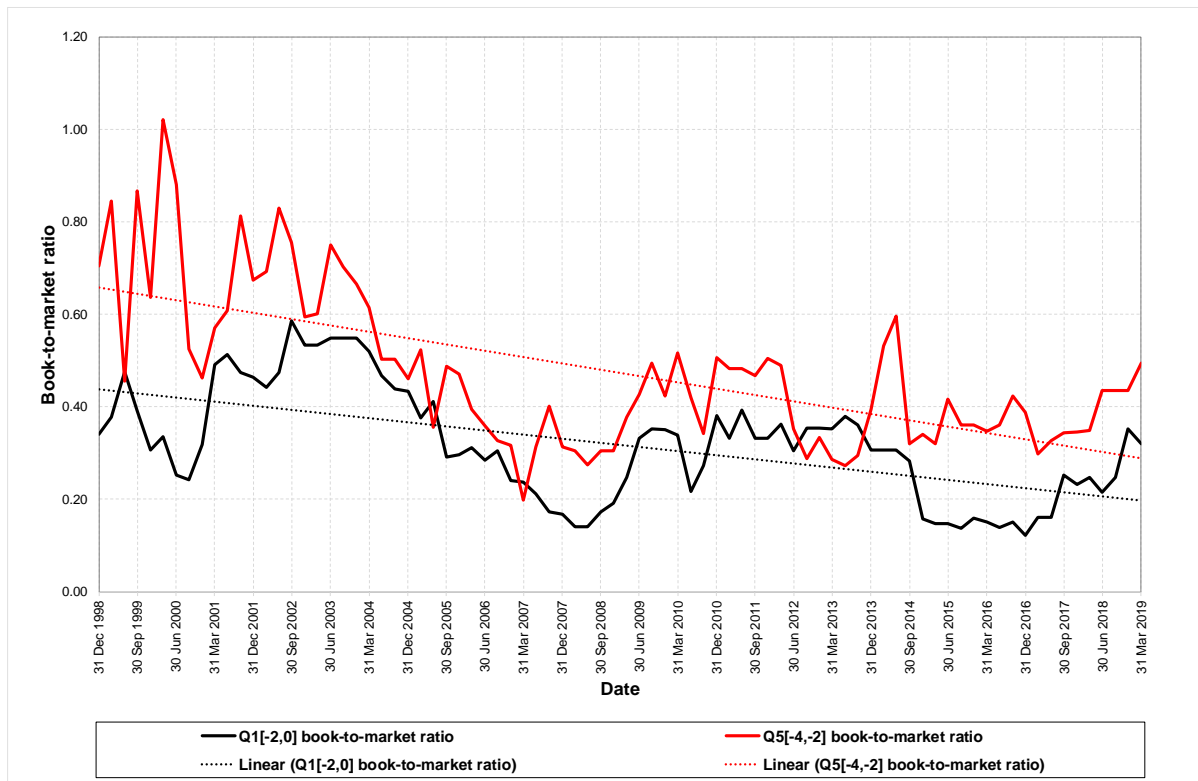
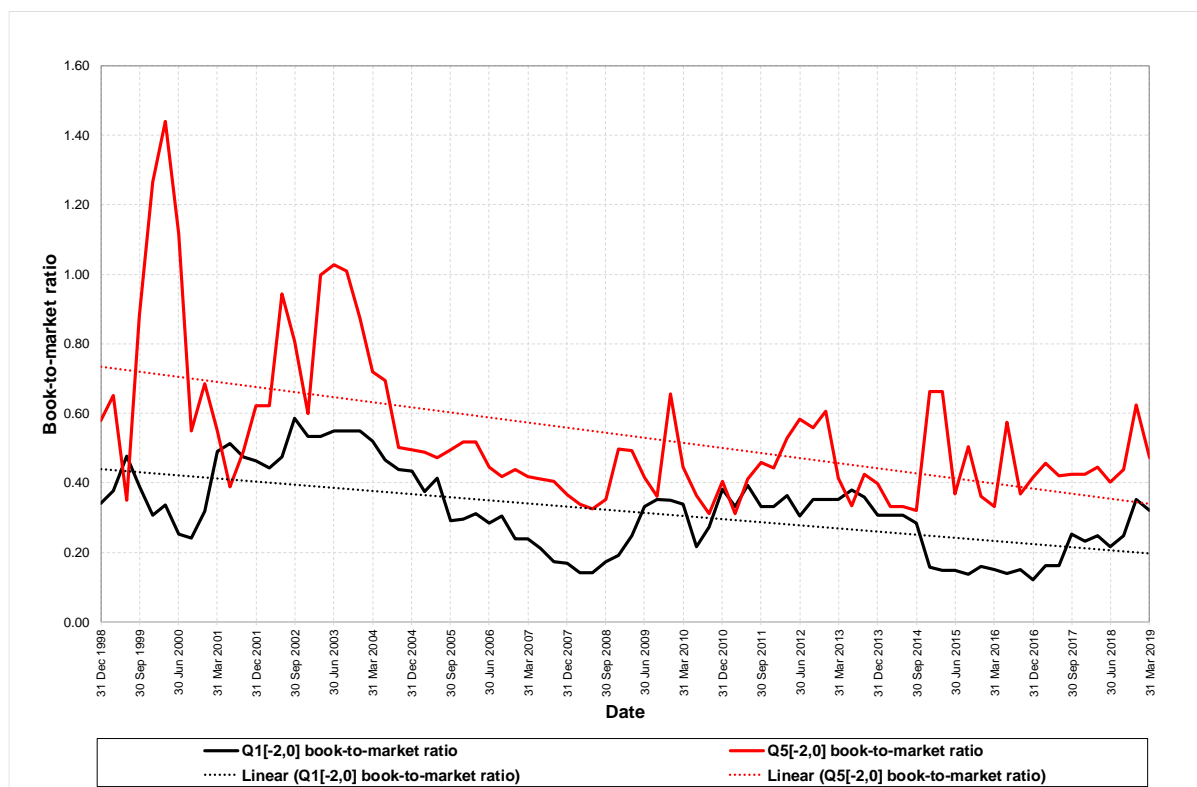
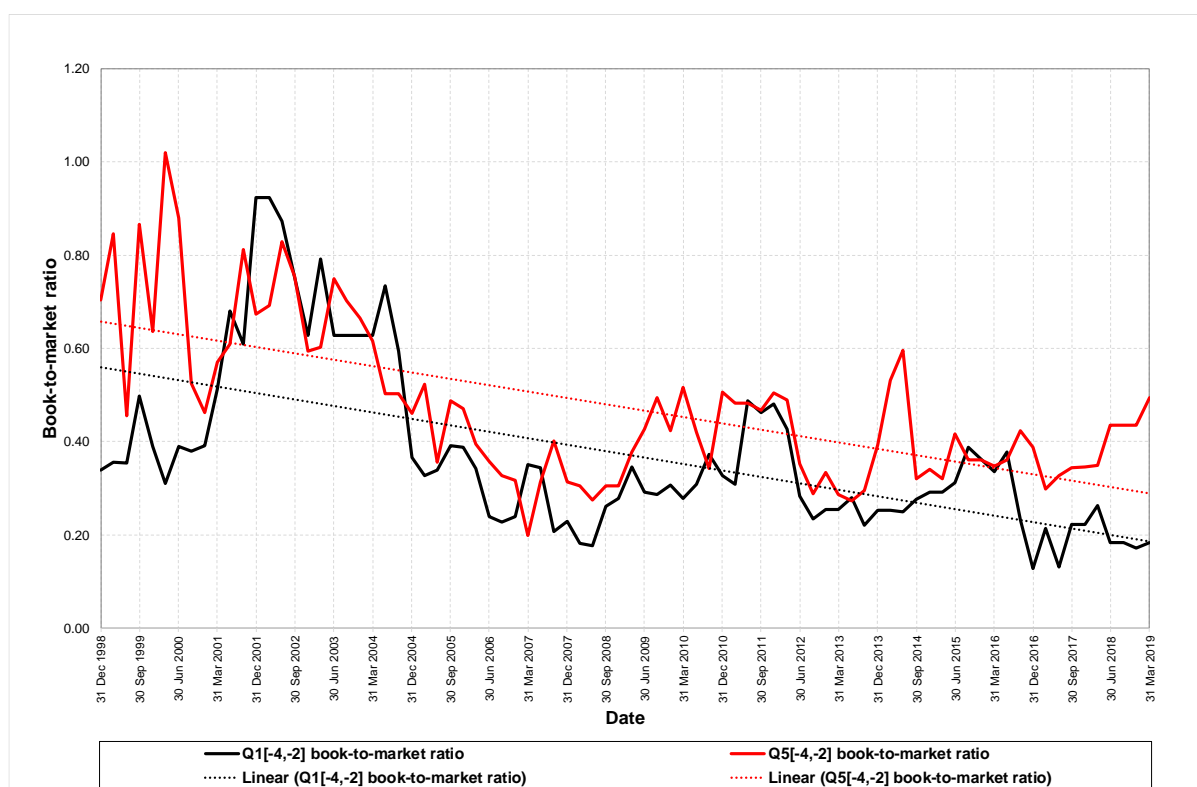


Figure A.5: Book-to-market ratio for Q1[-2,0] and Q5[-4,-2] (optimised case)



**Figure A.6: Book-to-market ratio for Q1[-2,0] and Q5[-2,0] (short horizon case)**



**Figure A.7: Book-to-market ratio for Q1[-4,-2] and Q5[-4,-2] (medium horizon case)**

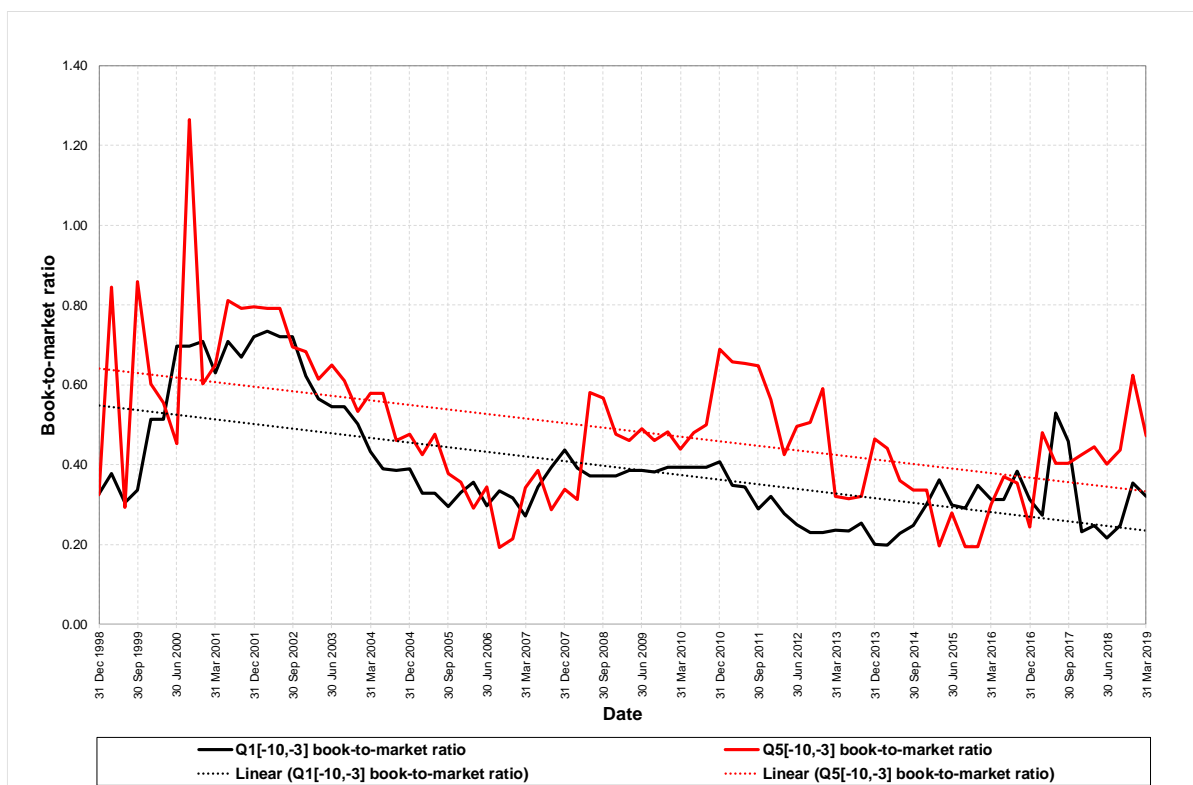


Figure A.8: Book-to-market ratio for Q1[-10,-3] and Q5[-10,-3] (long horizon case)

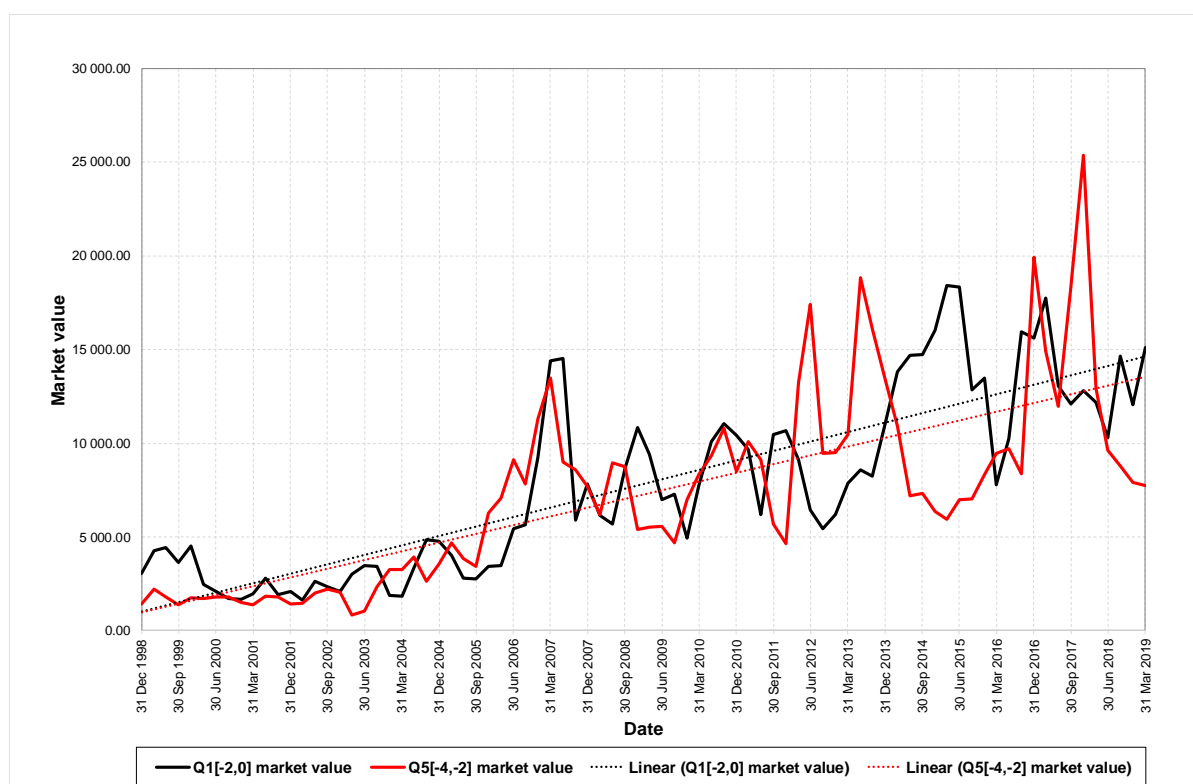
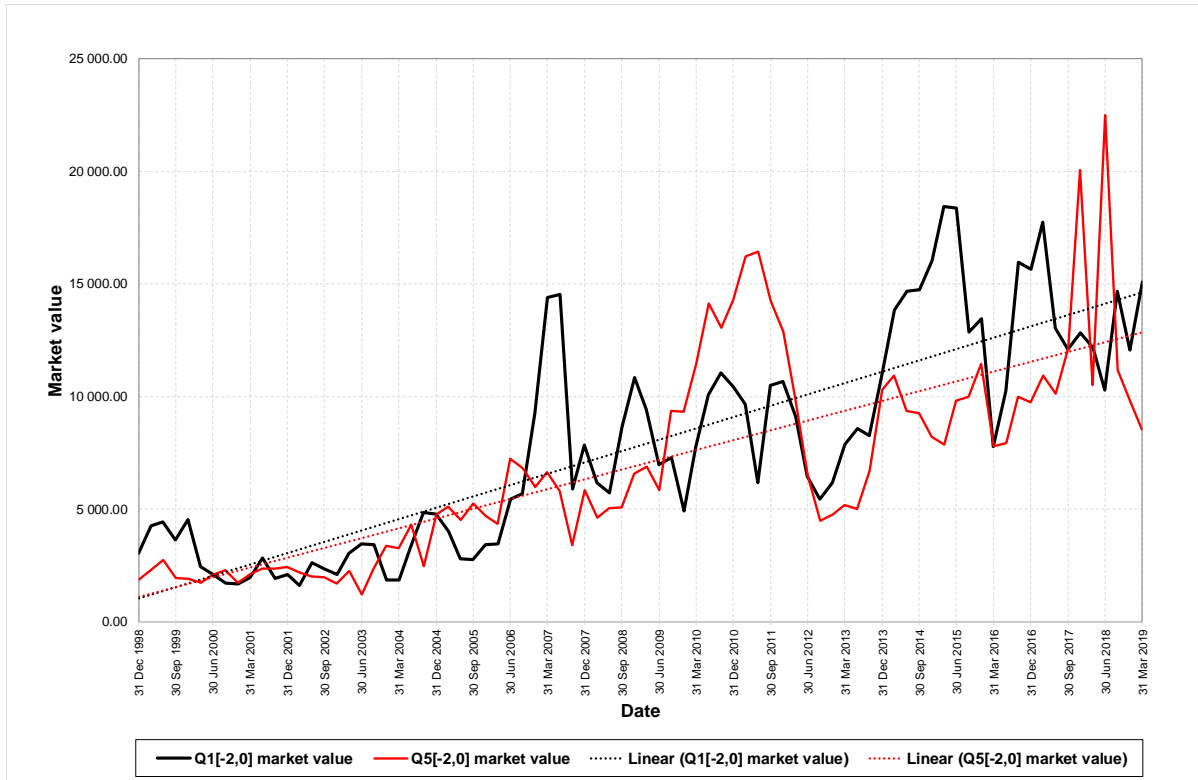
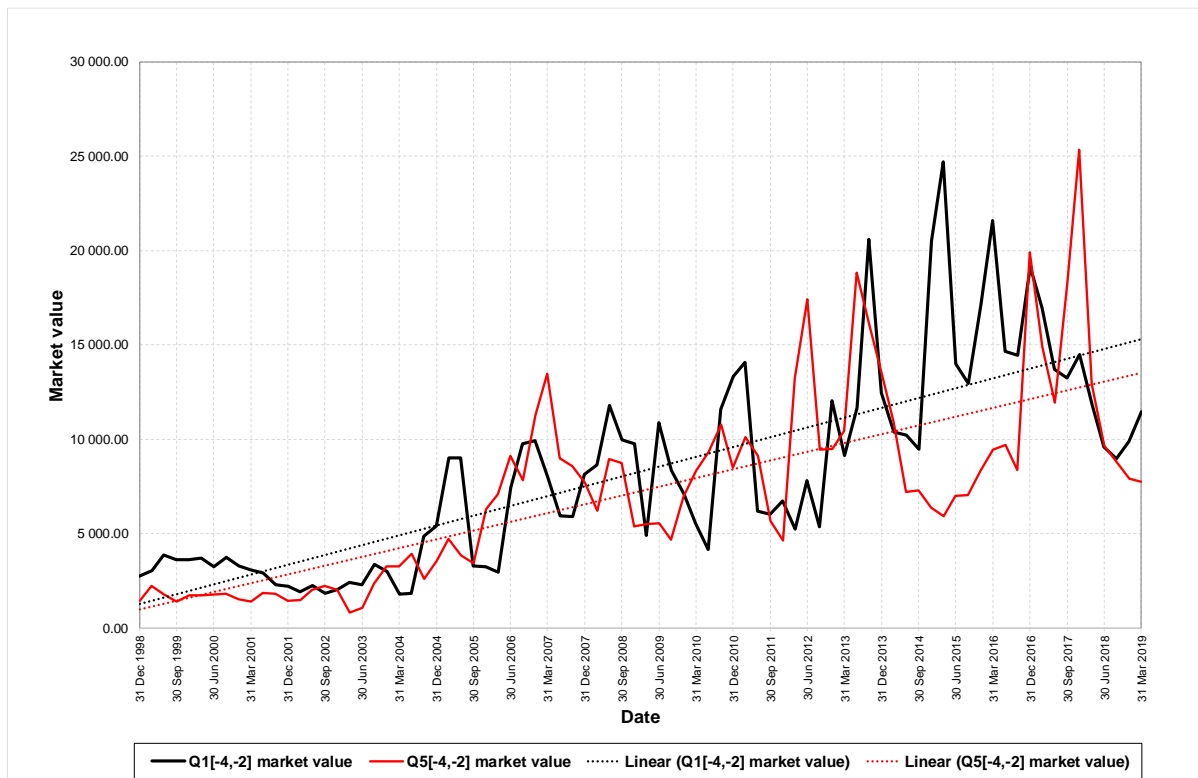


Figure A.9: Market value for Q1[-2,0] and Q5[-4,-2] (optimised case)



**Figure A.10: Market value for Q1[-2,0] and Q5[-2,0] (short horizon case)**



**Figure A.11: Market value for Q1[-4,-2] and Q5[-4,-2] (medium horizon case)**

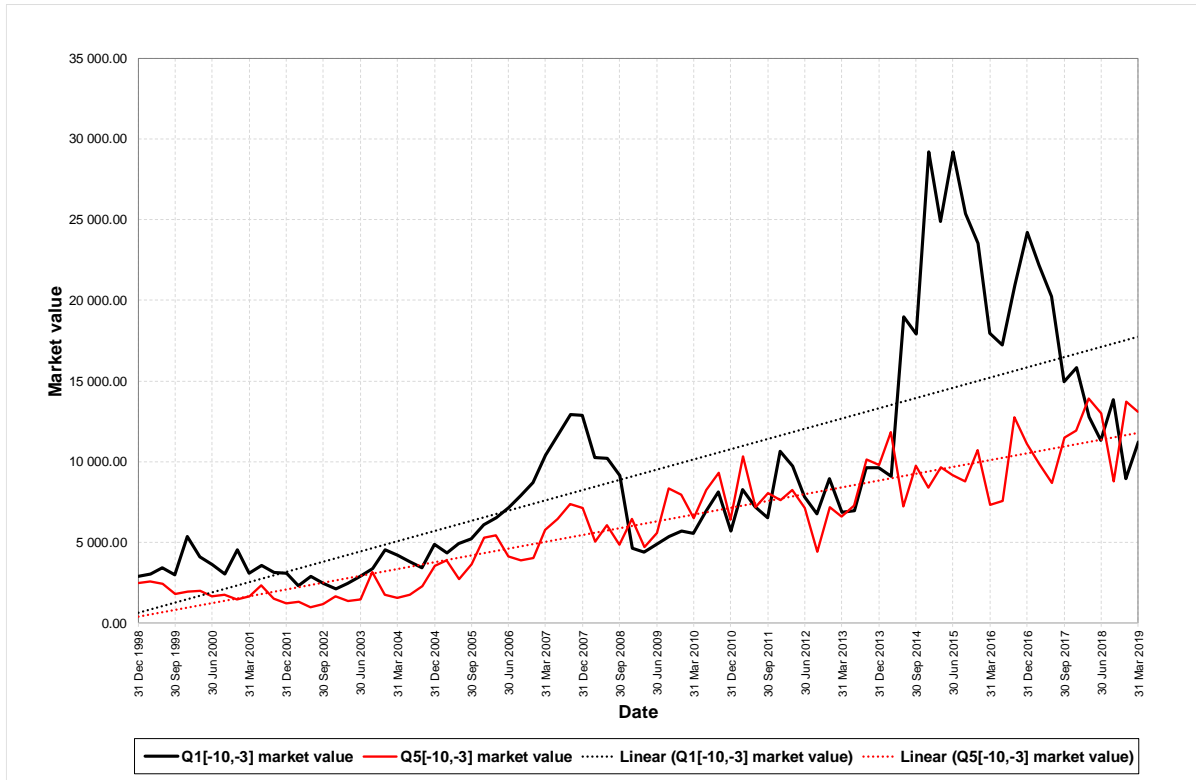


Figure A.12: Market value for Q1[-10,-3] and Q5[-10,-3] (long horizon case)

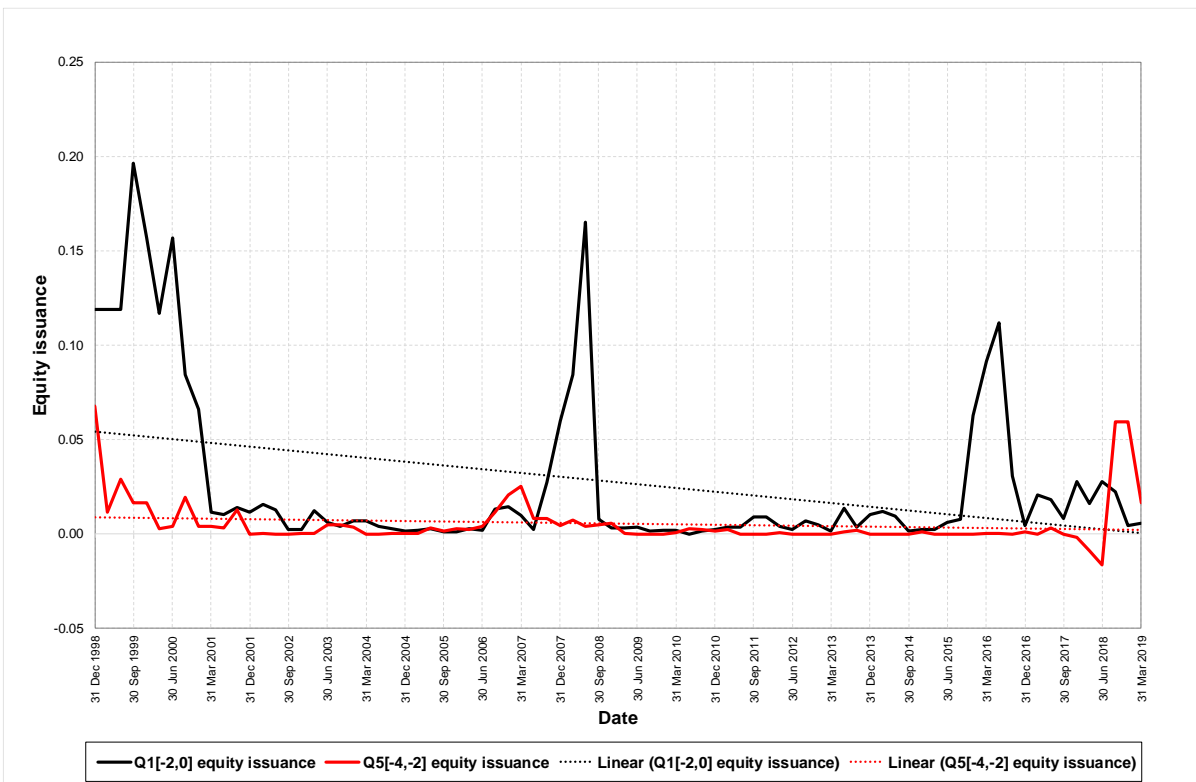


Figure A.13: Equity issuance for Q1[-2,0] and Q5[-4,-2] (optimised case)



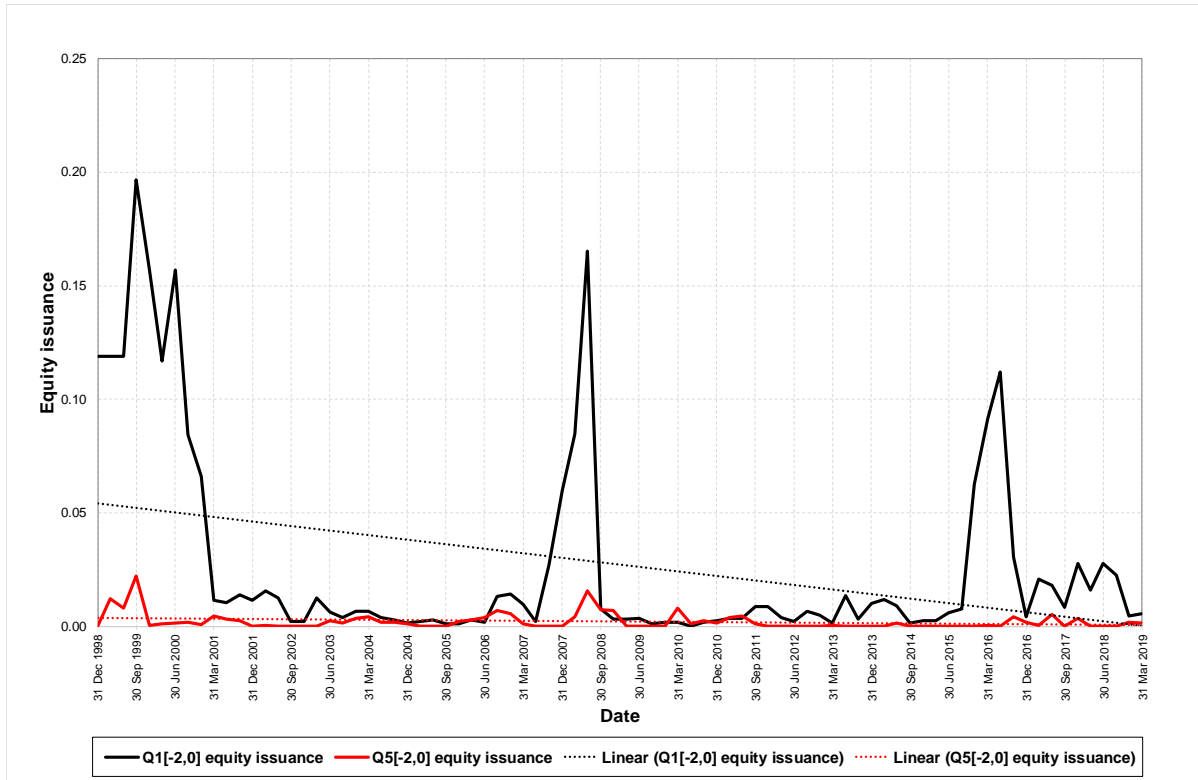


Figure A.14: Equity issuance for Q1[-2,0] and Q5[-2,0] (short horizon case)

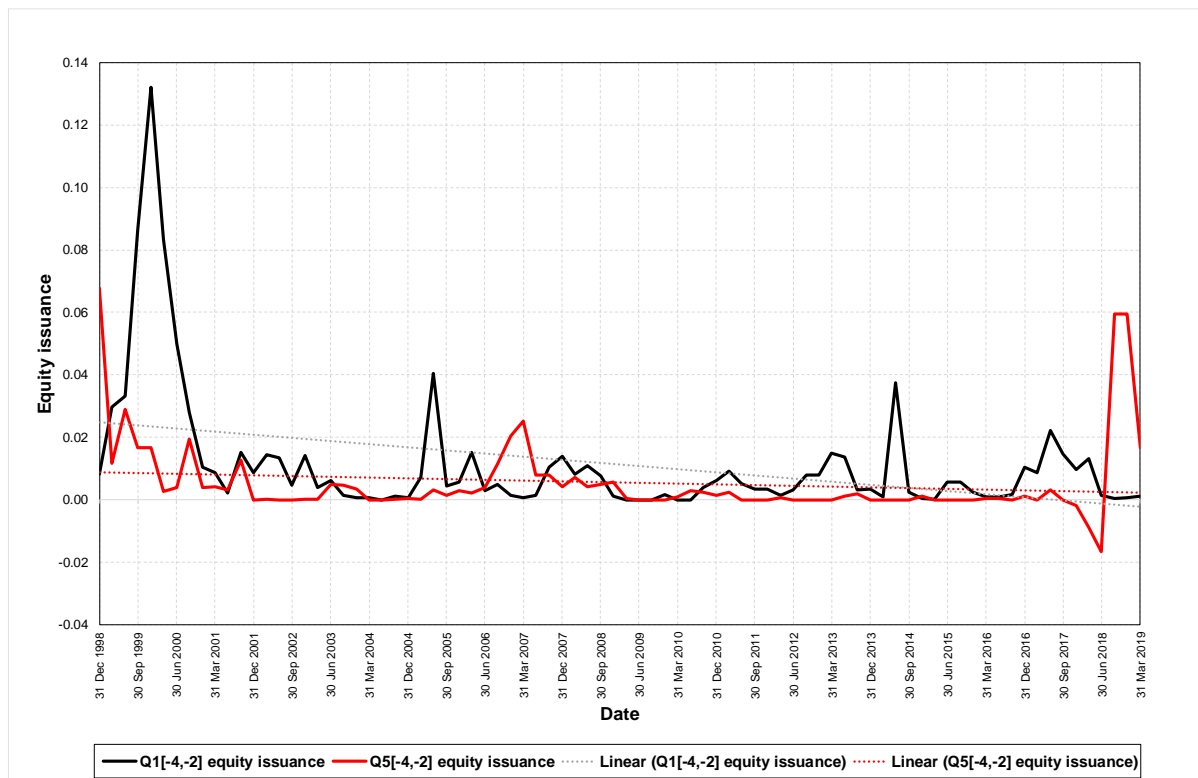


Figure A.15: Equity issuance for Q1[-4,-2] and Q5[-4,-2] (medium horizon case)

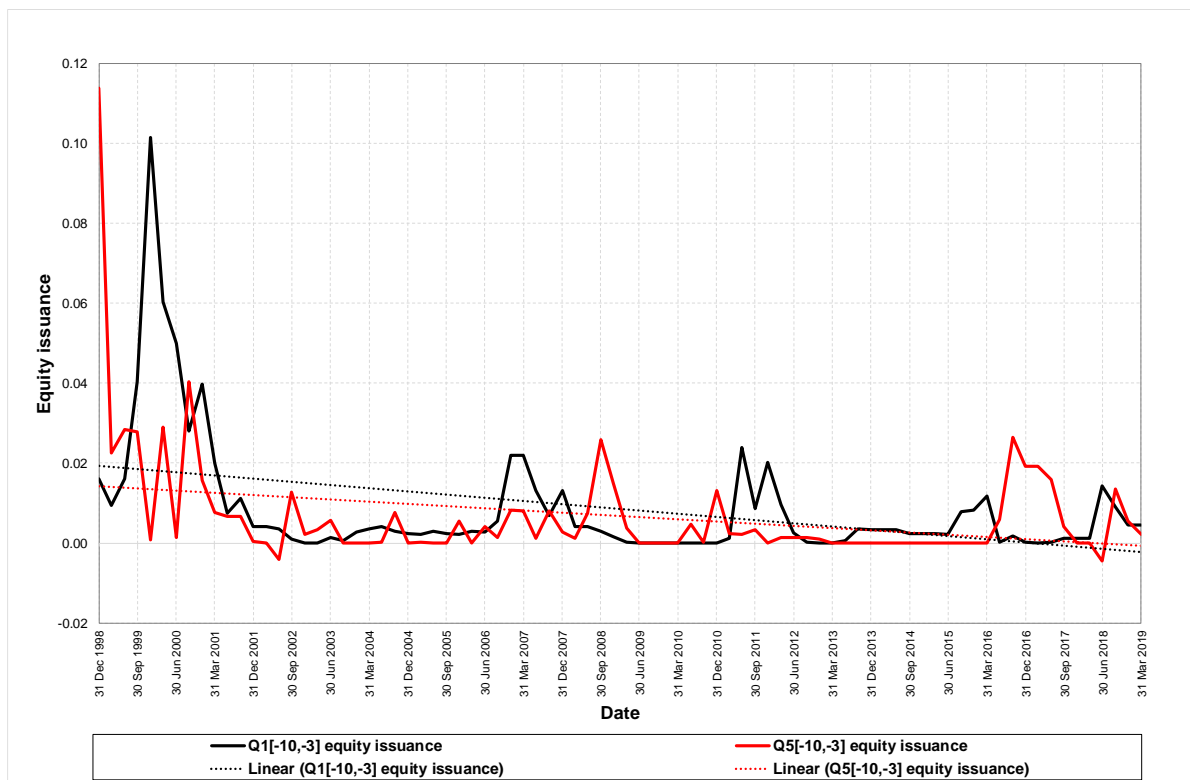


Figure A.16: Equity issuance for Q1[-10,-3] and Q5[-10,-3] (long horizon case)

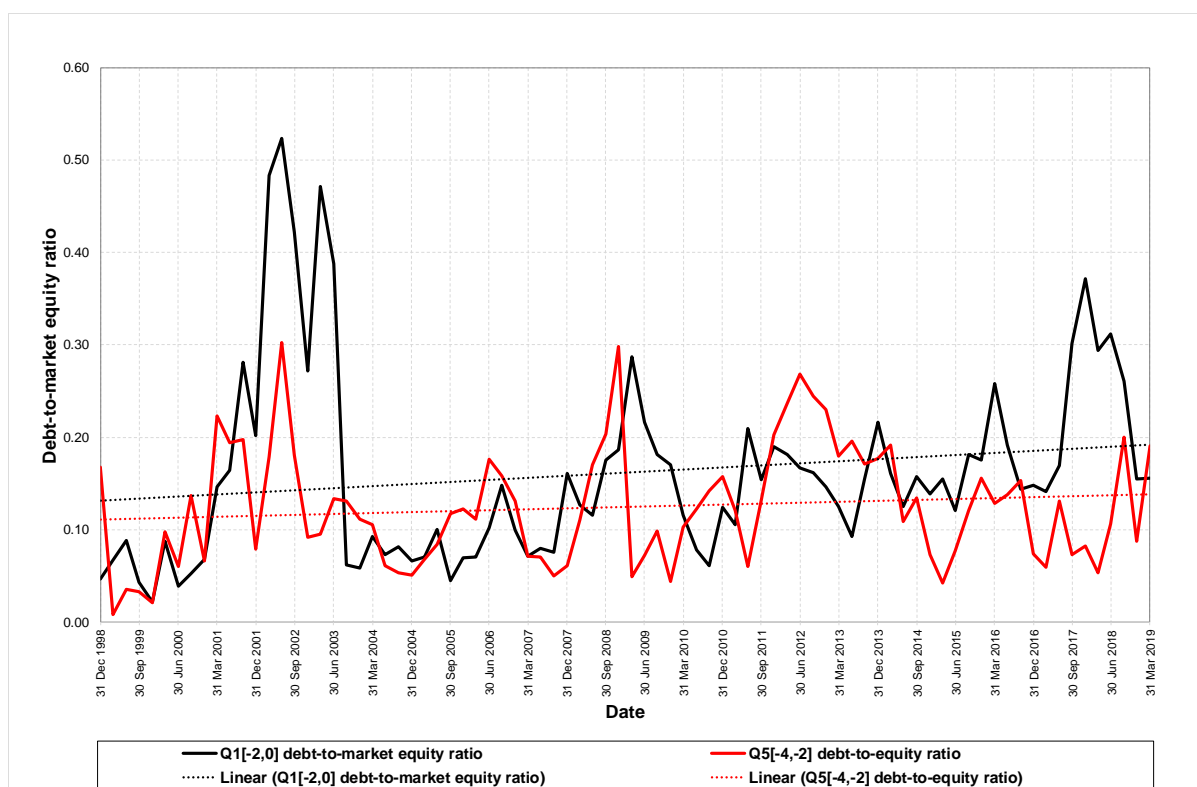
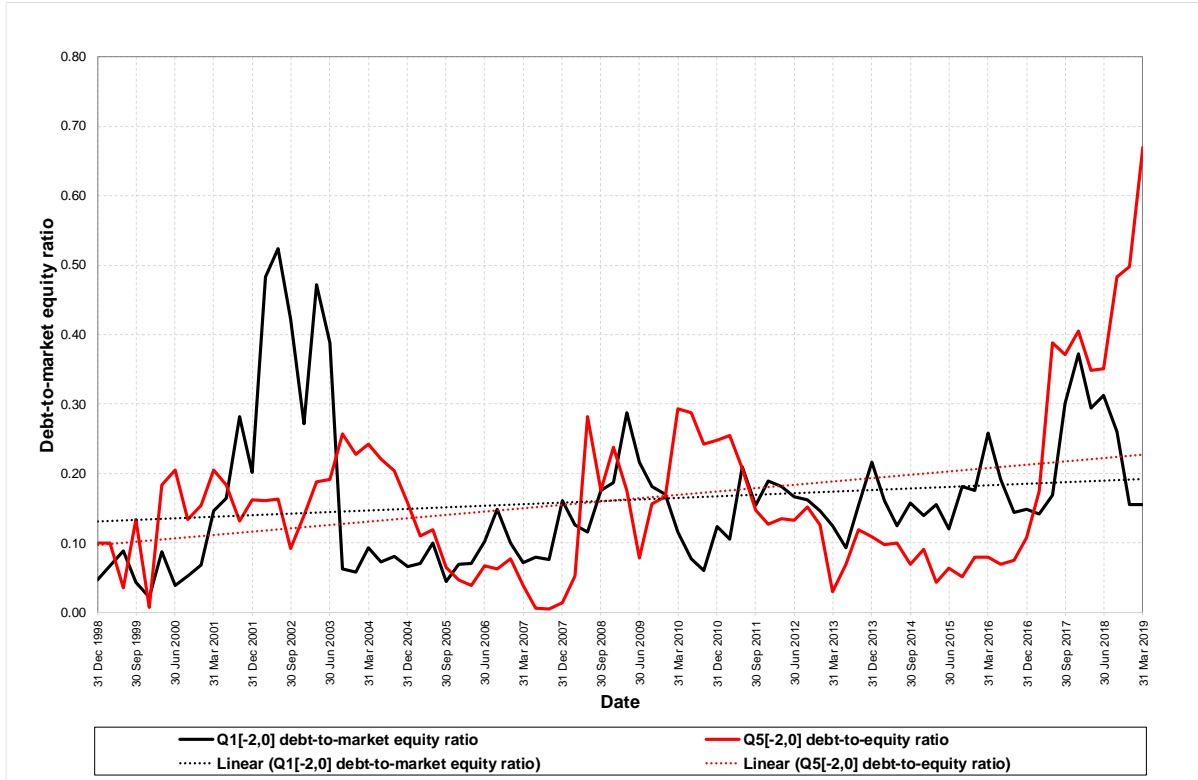
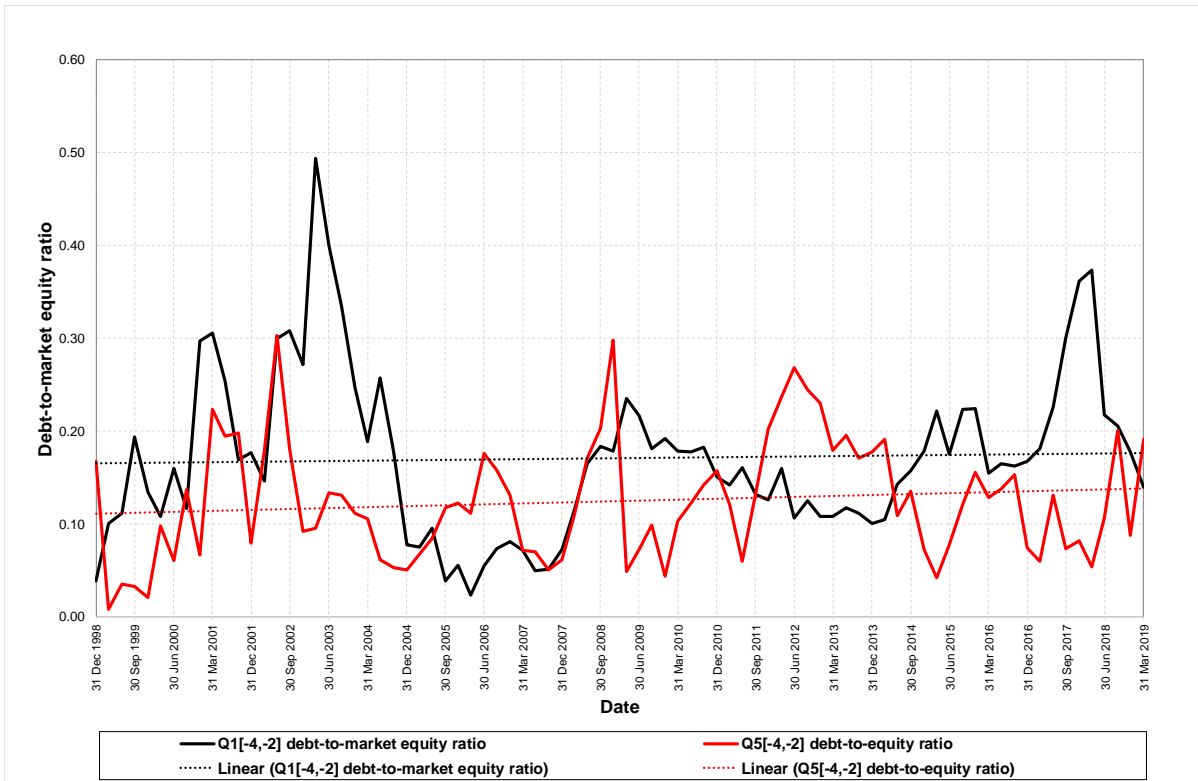


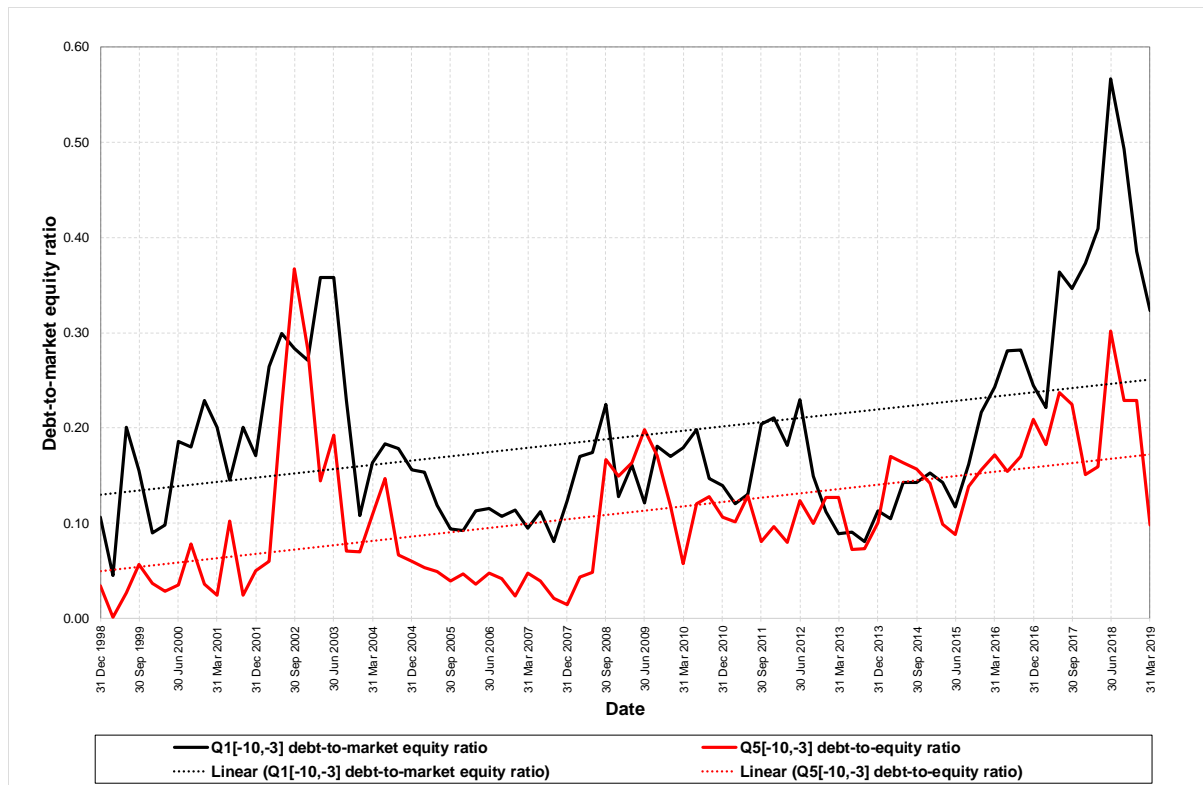
Figure A.17: Debt-to-market equity ratio for Q1[-2,0] and Q5[-4,-2] (optimised case)



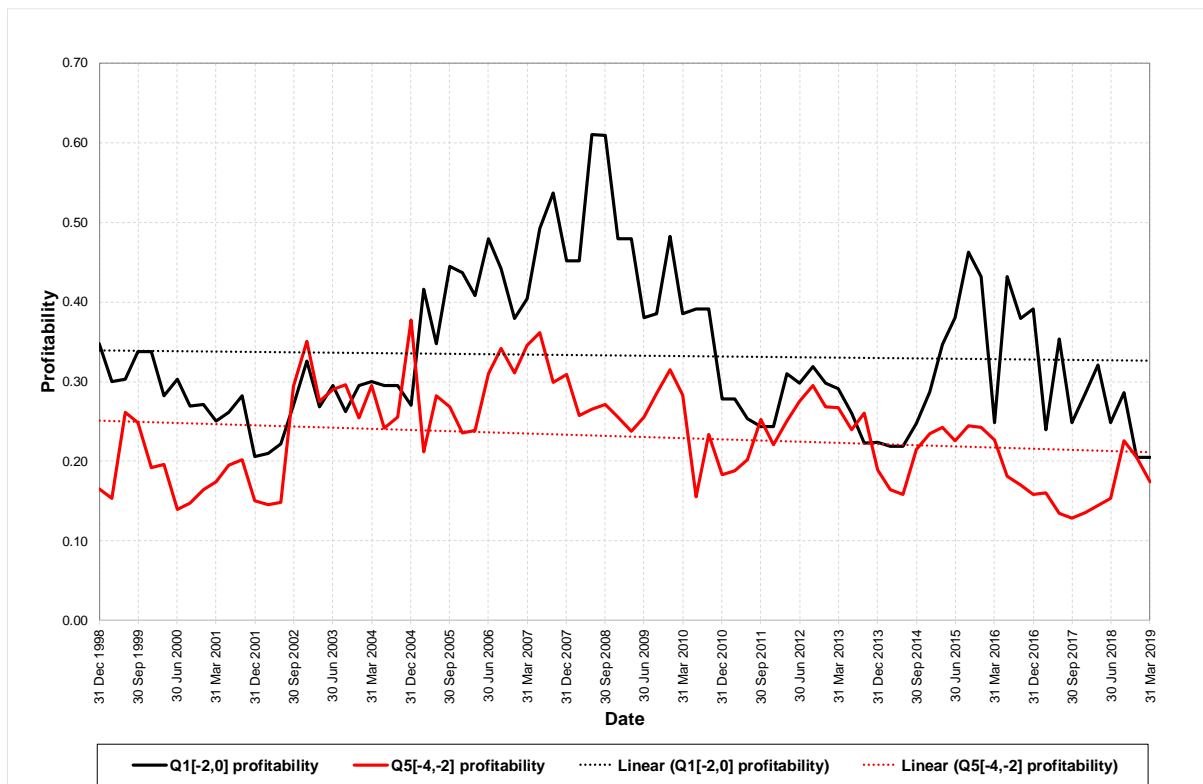
**Figure A.18: Debt-to-market equity for Q1[-2,0] and Q5[-2,0] (short horizon)**



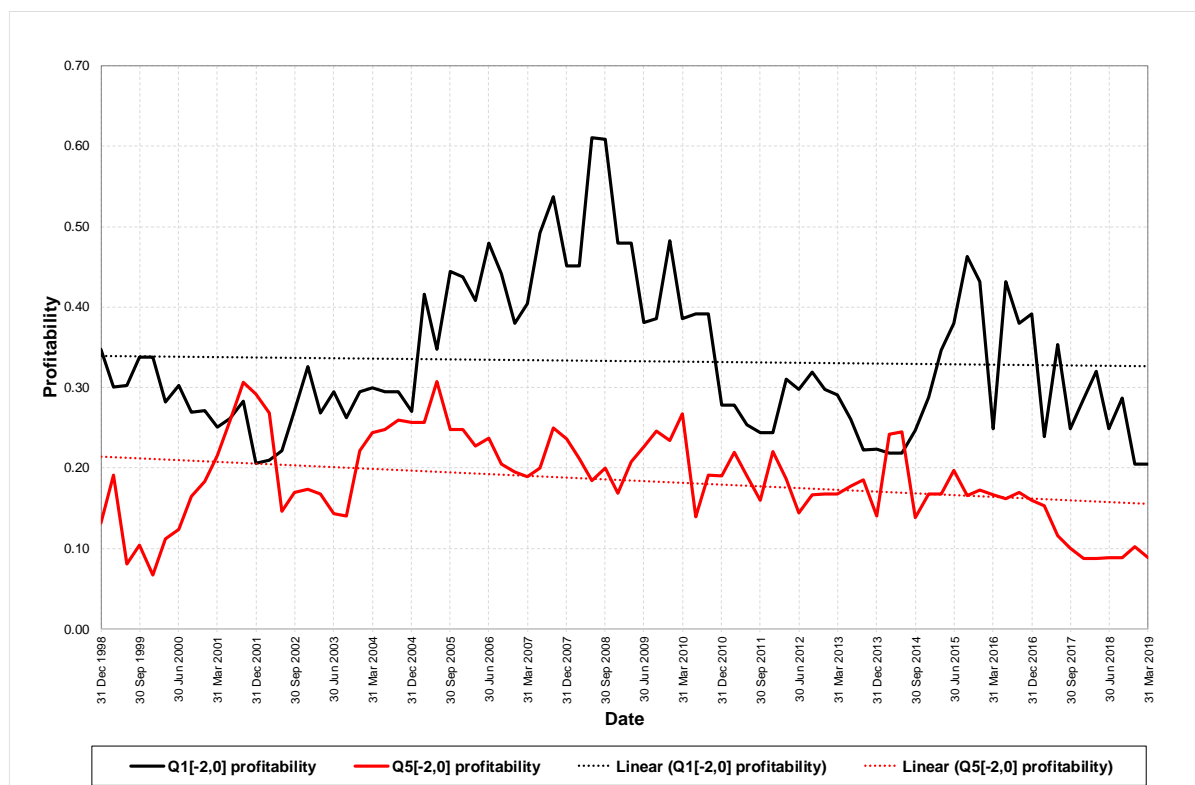
**Figure A.19: Debt-to-market equity for Q1[-4,-2] and Q5[-4,-2] (medium horizon)**



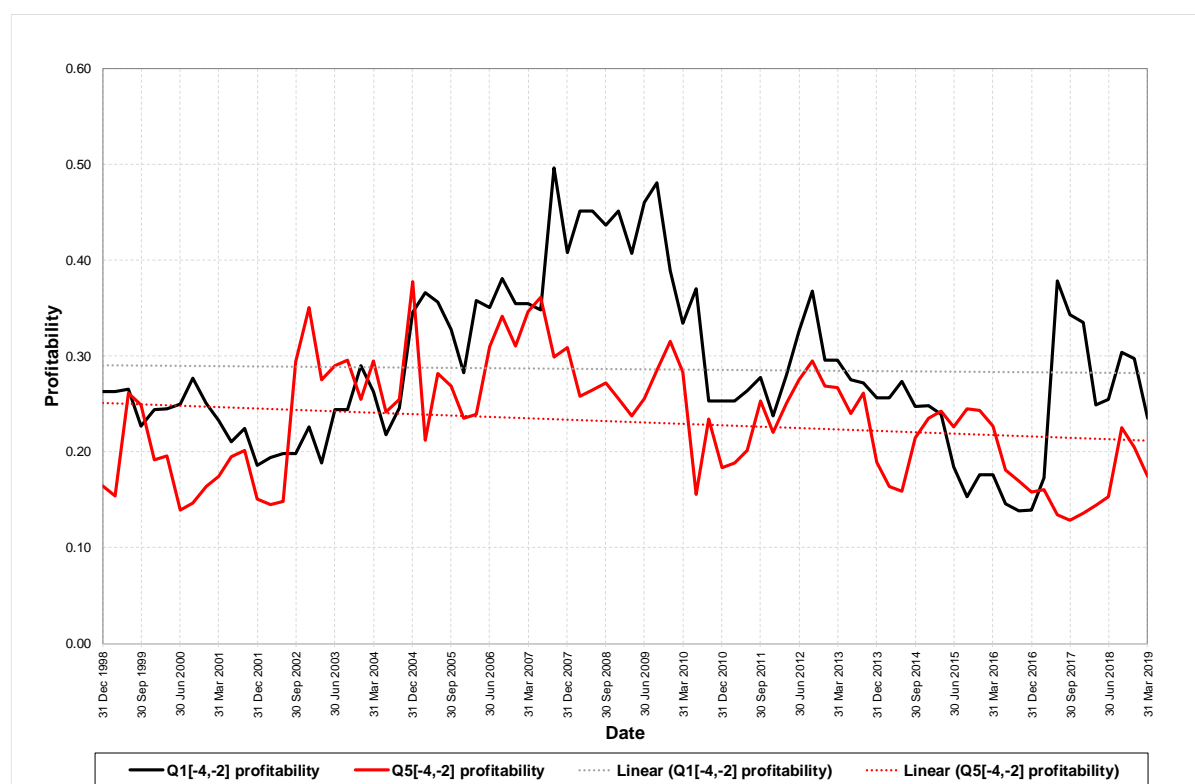
**Figure A.20: Debt-to-market equity for Q1[-10,-3] and Q5[-10,-3] (long horizon)**



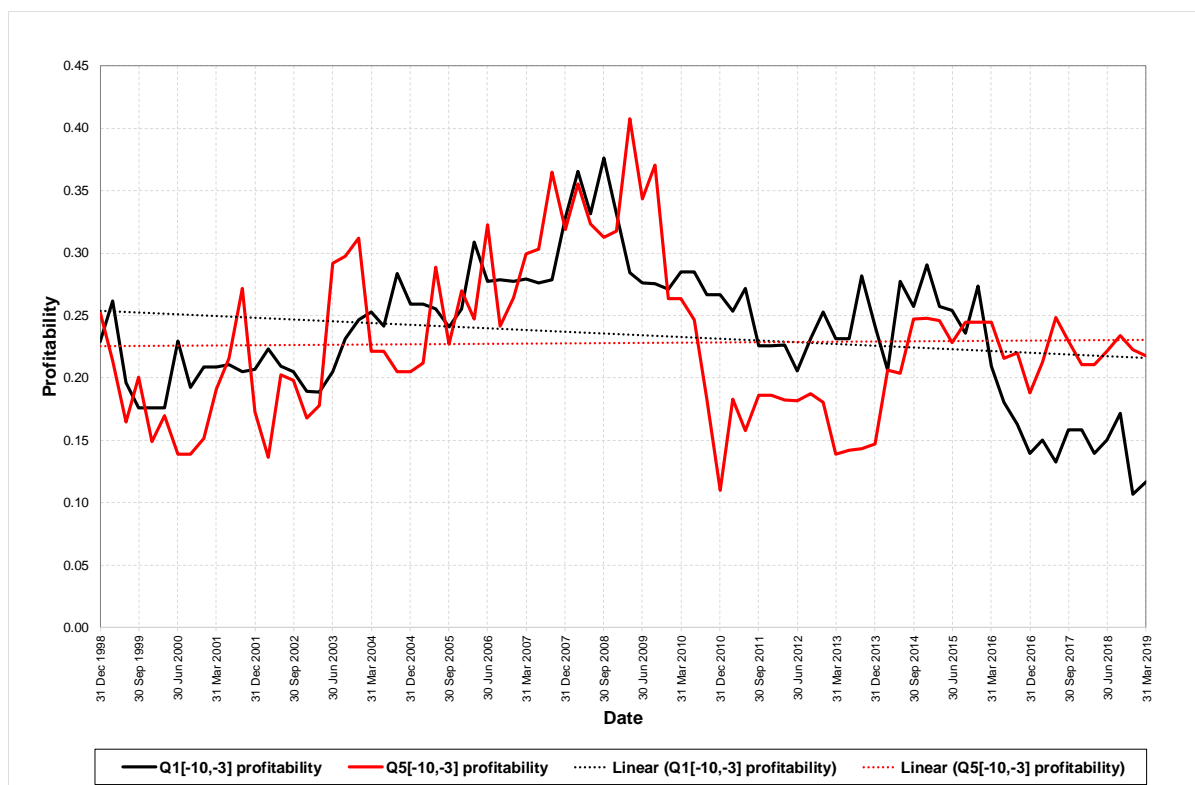
**Figure A.21: Profitability for Q1[-2,0] and Q5[-4,-2] (optimised case)**



**Figure A.22: Profitability for Q1[-2,0] and Q5[-2,0] (short horizon case)**



**Figure A.23: Profitability for Q1[-4,-2] and Q5[-4,-2] (medium horizon case)**



**Figure A.24: Profitability for Q1[-10,-3] and Q5[-10,-3] (long horizon case)**