The Market Value of R&D Investments Made by Companies Listed on the Johannesburg Stock Exchange

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A research report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Administration

Johannesburg, 2013

ABSTRACT

It is a prevailing view that South Africa under-invests in innovation. R&D spend is consistently less than 1% of GDP, which is well below benchmarks set by developed countries. The current research is concerned with R&D investments made by the listed business sector. Specifically, the question of whether R&D investments made by JSE listed companies are valued by the market is addressed, and whether these investments are reflected in the share prices. A cross sectional study has been carried out, in order to measure the impact of R&D investments on market value. The research methodology is based on previous studies carried out in developed and developing economies. Following a previous Canadian study, a linear regression model with market value as the dependent variable, and independent variables including book value, abnormal earnings, R&D spend, and net investment, is used. The period chosen for the study is the 5-year period from July 2007 to July 2012. Price data were obtained from the I-Net Bridge database. Data on book value, earnings, R&D spend, and net investment were obtained from financial statements as documented in the McGregor BFA database. This resulted in a panel dataset, for a cross section of companies over the study period. The study was not limited to any specific sector. Only the financial services sector was excluded, due to the specialised nature of valuation methods for such companies. It was found that approximately 60 companies report R&D expenses each year, with an annual spend by JSE companies of approximately R5bn. R&D investment is, however, highly concentrated, with 10 companies accounting for 80% of this spend. The linear regression analysis concludes that R&D spend is an insignificant predictor of market value. The research, therefore, fails to reject the null hypothesis that R&D activity has no impact on market value. The market value of JSE listed companies can be explained to a large degree (R^2>90%) by the book value and abnormal earnings variables. This result indicates that short term parameters (book value and current earnings) are the primary drivers of market value on the JSE. While the literature, covering studies in a number of countries, obtains similar results, most do observe a positive effect of R&D on market value. The current result may reflect a short term focus of investors during the volatile period chosen for the study. It is clear,

however, that innovative activity, on average, plays a very minor role in the fortunes of the listed business sector in South Africa.

DECLARATION

I, Graeme John Hill, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Signed at ………………………………………………….

On the …………………………….. day of ………………………… 2013

DEDICATION

To my family, Fatima, Jed, and Hannah, for their patience during the completion of this work, and to my late father, Quentin Concannon Hill, for giving me the chance to do it in the first place.

ACKNOWLEGEMENT

I acknowledge the guidance and advice given by my supervisor, Dr. Thabo Mosala. I also thank Stetson Haufiku of DMSA for reviewing the statistical analysis, and making valuable recommendations.

I acknowledge Nadir Thokan of 27four Investment Managers, for providing beta values for the companies used in this research.

Thanks also to Adele Mostert for editing the final manuscript.

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1 INTRODUCTION

1.1 Purpose of the study

The purpose of this study is to determine whether the South African stock market recognises any future benefits due to Research and Development (R&D) investments made by companies listed on the Johannesburg Stock Exchange (JSE). Do South African investors factor potentially superior earnings generated by R&D investment into their investment decisions and company valuations, or are such investments considered too risky to warrant any significant net present value?

1.2 Context of the study

Globally, R&D is carried out in both the public and private sectors. The outcome of R&D activity at universities and government institutions is usually a public good, available to anyone to exploit. With the development of intellectual property rights, however, the role of the private sector in R&D has become increasingly important.

Companies conduct R&D in order to improve their competitive position through improved products and services, or improved processes and efficiencies. Industries in which technology has a high impact typically benefit more from R&D than those where it does not. Traditionally the electronics, manufacturing, pharmaceuticals, and industrial processing industries are more likely to engage in R&D activity. The uncertainties and long payback times involved in R&D, however, make such investment decisions difficult. Returns on investment in new plant may be fairly straightforward to estimate. Developing a new drug or a new piece of equipment, in contrast, carries both technical and market risk, making returns difficult to calculate.

In most countries generally accepted accounting principles (GAAP) stipulate that R&D investments are expensed as incurred, rather than capitalised. This is also the case in South Africa (Opperman and Booysen, 1998). It has been widely argued that this practice leads to a disincentive for managers to make R&D investments, as it directly reduces bottom line. Pressures to maximise short term profit lead to an overly conservative approach to R&D. (See, for example, (Knott, 2012).)

It is generally accepted that the bulk of R&D and new product development is carried out by developed economies, and this is borne out by statistics on the percentage of GDP made up by R&D activity. The US remains the top spender on R&D, with an estimated spending of $405 billion in 2011, which represents 2.7% of GDP (Grueber and Studt, 2010). According to the same source, South Africa ranked 30th in terms of global R&D spending – USD 3.7 billion, representing 0.7% of GDP. The distribution of South African R&D spending across business enterprise, government, higher education, non-profit organisations, and science councils is estimated in an official government survey (Blankley, 2011). For the 2008/2009 period, South Africa spent R21 billion on R&D. The business sector accounted for the majority of this at 58.6%. Higher education centres and science councils contributed 20% and 15%, respectively (Blankley, 2011).

The South African government sees R&D as an important source of economic growth, and has developed strategies such as the Research and Development Tax Incentive Scheme to encourage increased local R&D investment (DST, 2011).

Possible reasons for the relatively low investment in R&D in South Africa, and developing economies in general, is the lack of skills and resources to effectively compete with countries like the US. Industry relies on imported innovation, rather than engaging in local developments. While government creates policy and directs funding to encourage R&D, the business sector in South Africa remains the major contributor to R&D spending. The question is whether the value of local R&D is recognised by the market.

1.3 Problem statement

1.3.1 *Research problem*

The research will establish whether Research and Development (R&D) investments made by JSE listed companies are reflected in their share prices. In other words, does the South African equities market recognise the future value of intangibles generated by R&D investments?

1.4 Significance of the study

The hypothesis that R&D investments of South African companies have a positive impact on their share prices is significant to both business and government. Should the hypothesis be accepted, it would indicate that investors capitalise the investments that companies make in R&D, despite the accounting practise of expensing such investments. For business managers, this would indicate that good R&D investment increases market value, and negates the fears that such investments are considered wasteful in that they erode the bottom line. An appreciation of this fact would free managers to take a longer term view and make investments that would improve their competitive position and grow their companies.

The rejection of the hypothesis would validate the generally held conception that South African investors do not view R&D as a value adding activity. This may be due to a view that South Africa is not competitive with respect to the development of innovative products and processes, or it may simply indicate a myopic view, in which investors focus on short term profit alone.

From the point of view of government, a positive outcome of the research would indicate that the market generally supports efforts to increase South Africa's competitiveness through local innovation. A negative outcome would show that government interventions, through research council funding, and the tax incentive scheme, are sorely needed.

1.5 Delimitations of the study

The sample in this study is constrained to companies listed on the main board of the JSE. This limitation was necessary since fairly detailed financial information, including market value, are required for the analysis. The conclusion, however, may generalise to the value of R&D activity carried out by all South African business. Furthermore, the results will also be significant for other small, developing economies.

The period chosen for the study will be July 2007 – July 2012. This provides a sufficiently extended period so that enough observations can be made for the regression analysis. It is an interesting period in that it contains the 2008/09 financial crisis. The effect of this is that cut-backs on investments by companies may reduce the amount of data available. It was decided, however, to keep the period current so as to make the results relevant to current investor behaviour. Effects due to the financial crisis may also be observed, which would be interesting and will be analysed further.

Due to the small number of firms which consistently do R&D in South Africa, it is anticipated that obtaining sufficient observations will be a challenge. The research will draw data from all companies that report R&D expenditures, as opposed to focusing on any particular industry. Only the financial services sector will be excluded, due to the specialised nature of valuation in this sector. The aim is to obtain a preliminary indication of the market valuation of R&D expenditure in South Africa, and will not attempt to go into detailed analysis of industry or company size effects.

1.6 Definition of terms

Research and Development (R&D): For the purpose of this research, R&D is defined as the creation of new products, processes, or knowledge through the application of basic and applied scientific research.

JSE: Johannesburg Stock Exchange.

Book Value: For the purpose of this research, book value is defined as the total value of the equity attributable to ordinary shareholders, as reported on the balance sheet.

Market Value: Share price at the end of the period, multiplied by ordinary shares outstanding.

1.7 Assumptions

The research employs a quantitative methodology based on financial data obtained from company annual reports. It is a fundamental assumption that reported R&D is legitimate, and that all R&D expenses are reported. The data acquisition methodology focuses on companies that consistently report R&D, which mitigates against any opportunistic R&D reporting that companies may engage in order to improve reported results. This assumption is discussed further in later chapters.

2 LITERATURE REVIEW

2.1 Introduction

The literature pertinent to the research problem is reviewed in this chapter. Various approaches to determining the impact of R&D have been described in the literature. Johnson and Pazderka (1993) provide a brief review of these. Case studies attempt to demonstrate the value-add of R&D by referring to outcomes of a specific research programme or to the developments made in a specific company or industry. These studies are time consuming, as they require large amounts of detailed information. Since they tend to focus on prominent and successful cases, they may not give an indication of the general impact of R&D (Johnson and Pazderka, 1993).

The rate of patent issuance is often considered as a proxy for inventive behaviour in business. The use of patents as an economic indicator has been discussed by Griliches (1998). Patents, however, are an indirect measure of R&D value-add, as they do not provide information on the economic benefits accrued to the patent holder.

Other studies use econometric methods to relate R&D investments to output measures such as growth, productivity, profitability, or production costs (Bandeira and Afonso, 2010). These methods can be applied at various levels: company, industry, or even the entire economy. Griliches (1979) provides a good overview of such methodologies, including the problems associated with them. These include the difficulty of measuring the dependent variables (growth, costs, profitability), and spill-over effects. The latter relate to the diffusion of innovations between companies and industries, leading to difficulties in associating productivity improvements to the efforts of a particular company or industry (Johnson and Pazderka, 1993).

The concept of using the market value of the company as the dependent variable in assessing the impact of R&D investment dates back to the 1980's (Griliches, 1984). This approach is based on the fact that R&D effort contributes to the stock of intangible assets held by the company. It should therefore reflect in the market's valuation of the company (Griliches, 1984). Rather than measuring the final outcome of R&D on productivity variables, it represents the market's view of the present value of future benefits (Griliches, 1984).

Empirical studies of the impact of R&D on company value use two different types of data (Johnson and Pazderka, 1993). The first investigates the response of the market to unexpected announcements of increases in R&D spending or the initiation of a new R&D programme. The second looks at the relationship between market value and reported (historical and current period) R&D expenditures (Johnson and Pazderka, 1993). The literature covering these two approaches are reviewed in sections 2.3 and 2.4, respectively.

The literature reviewed in sections 2.3 and 2.4 covers a range of economies, including the US, UK, Australia, Canada, and Taiwan. Section 2.5 reviews a study carried out on South African companies. The chapter concludes with the statement of the research hypothesis, to be tested by quantitative means, concerning the market valuation of R&D in South Africa.

2.2 Definition of topic

This research falls in the field of econometrics, specifically with respect to the economic impact of innovation. It has relevance to the field of technology and R&D strategy.

2.3 Market Value Methods: New News

Several studies have used an event based methodology to investigate the response of the market to unexpected announcements by companies of increases in R&D spending. These studies typically measure abnormal returns of the companies making announcements over a period preceding, during, and following the announcement (Szewczyk, Tsetsekos and Zantout, 1996) (Li, Lin and Hong, 2011) (Bhana, 2001).

Szewczik, Tsetsekos, and Zantout (1996) used a sample of 252 announcements by 121 US companies over the period 1979 to 1992. The authors observed a significantly positive cumulated average normal return during the announcement period – the returns increased from a small and negative base to 0.477%. Evidence from earlier work suggests that the effect is greater in high technology industries compared to low technology industries (Chan, Martin and Kensinger, 1990). This would suggest that the market expects greater benefit from R&D in high technology industries.

Li, Lin, and Hong (2011) carried out a similar study in Taiwan. These authors used 1197 observations for the period 1988 – 2007. In contrast to the US study by Szewczik, Tsetsekos, and Zantout (1996), these authors observe no significant increase in abnormal returns for announcing companies.

A study by Bhana (2001) on JSE listed companies reveals a significant positive effect of R&D announcements on abnormal returns. This work is reviewed in more detail in section 2.5.

This literature suggests that the market does respond positively to R&D announcements, but that the effect depends on the type of industry, and may also vary depending on the nature of the economy in which the study is carried out.

2.4 Market Value Methods: R&D Stock and Flow

There is a substantial literature employing cross-sectional regression methodologies to investigate the impact of R&D investment on the market value of companies. These methods view R&D investment as contributing to the stock of intangible assets of the firm. The value of the firm can be considered as the sum of its tangible and intangible assets. Ben-Zion (1984) developed a formalism which has been used in many subsequent empirical studies. According to Ben-Zion (1984), the value of the firm is made up of tangible assets, represented by the common equity, or book value, and its intangible assets. Intangible assets are made up of the "monopoly power" of the firm, the stock of R&D investments made by the firm, and knowledge represented by patents (Ben-Zion, 1984). The author defines "monopoly power" as those intangible assets that give it the ability to earn above normal returns.

Ben-Zion (1984) formalises the approach by expressing the market value (*MV*) of a company as follows:

$$MV = \alpha_1 BV + \alpha_2 KM + \alpha_3 KRD + \alpha_4 KN,$$

where *BV* is the book value, *KM* is the monopoly power, *KRD* is a measure of the stock of R&D, and *KN* is a measure of the value of the company's stock of patents.

Ben-Zion (1984) approximates the stock of R&D investments as follows:

$$KRD_t = \sum_{k=0}^{\infty} RD_{t-k}(1-\delta)k = \beta_2 RD_t.$$

The index t represents the current financial period, and t - k are previous periods. This equation represents R&D stock as the sum of previous R&D investments (RD_{t-k}) up to the current period, depreciated using a factor δ. The author further approximates the stock of R&D by the current level of R&D (RD_t), assuming a constant growth rate with $\beta_2 = 1/[1 - g - \delta],$ where g is the growth rate in R&D investment. This last assumption simplifies data collection in empirical studies, as only current levels of R&D investment (flow variable) are required, as opposed to the accumulated, and depreciated, stock variable. The use of the current R&D flow variable also helps by avoiding the need to track capitalisation of R&D expenses, which companies do from time to time, when the benefits of the R&D outcome become quantifiable. The assumption amounts to treating current R&D investment as a proxy for innovative activity by the company.

The "monopoly power" is assumed to be proportional to the abnormal earnings of the company: $KM = \beta_1 E^*$, where the above normal earnings $E^* = E + R\&D - \rho BV - \delta KRD$ (Ben-Zion, 1984). Here R&D is added back to accounting earnings E since they are accounted for as expenses. ρ, according to Ben-Zion (1984) is the normal return on equity. A later study by Johnson and Pazderka (1993) uses the modern notation of cost-of-capital k, ie. $E^* = NI - kBV$, where NI denotes net income.

Ben-Zion (1984) estimates the value of patents by assuming the value to a company is proportional to the number of patents held by the company P, and the number of patents held by the industry PT: $KN = \beta_3 P + \beta_4 PT$.

By substituting these approximations into the market value (MV) formula above, and assuming for simplicity that $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$, Ben-Zion (1984) arrives at the following approximation:

$$lnMV = (ln\alpha_1 - \rho) + \beta_0 lnBV + \beta_1 \frac{E^*}{BV} + \beta_2 \frac{RD}{BV} + \beta_3 \frac{P}{BV} + \beta_4 \frac{PT}{BV} + \beta_5 \frac{INV}{BV}. \quad \text{2-1}$$

Here β_0 is expected to be unity. Note that the author has included a control variable for the net investment of the firm *INV* in equation 2-1. This is based on an argument that the value effects of R&D investment may simply relate to investors taking them as a signal of market opportunities identified by the company's management. Inclusion of the *INV* term is to control for this effect.

Ben-Zion (1984) applied the estimation equation 2-1 to a database of 93 US firms that reported R&D expenditures in the period 1969-77. The author's regression analysis yielded significantly positive values for the coefficients of the *RD*, *INV* and *E** variables. Specifically, a one dollar investment in R&D increased the market value by a factor 3.3, relative to one dollar of its book value.

Interestingly, Ben-Zion (1984) found that the firm patent variable *P* was insignificant, but that the overall industry patent variable *TP* was significantly positive. The author suggests that the weak effect of a firms own patents is due to that market's uncertainty of whether patents applied for will indeed be granted. In the industry patent case, where a stronger contribution to *MV* is obtained, Ben-Zion (1984) suggests that this variable plays the role of a proxy for the expected growth of the industry as a whole. Johnson and Pazderka (1993) observe that studies which include the company patent variable, but exclude R&D investment, do obtain significant and positive values for the patent variable coefficient. When R&D is included, the patent variable becomes insignificant. These authors conclude that number of patents is a "noisy" variable, and that the market considers R&D investment as a better indication of innovative activity.

Johnson and Pazderke (1993) have applied the Ben-Zion approach (Ben-Zion, 1984) described above to a sample of listed companies in Canada. Based on the argument above, patent variables are excluded, and these authors use the following estimation equation:

$$lnMV = \beta_0 + \beta_1 lnBV + \beta_2 \frac{E^*}{BV} + \beta_3 \frac{RD}{BV} + \beta_4 \frac{INV}{BV} + \varepsilon. \qquad \text{2-2}$$

Here *E** = *NI* – *kBV* represents abnormal earnings, where *NI* denotes net income and *k* is the company's cost-of-capital. ε is a random error term.

One of the problems in applying a regression analysis is the amount of data that are available. The number of companies reporting R&D expenses in any single year is not great, and this is specifically true in small economies such as South Africa. In their Canadian study, Johnson and Pazderka (1993) used panels of data, involving a number of companies reporting R&D spending over consecutive years. These authors identified three periods (1985-7, 1986-8, and 1985-8) in which 52, 54, and 47 companies provided consecutive R&D data, together with all the other variables required by equation 2-2. Pooling these data led to three balanced datasets of 156, 162, and 188 observations, respectively.

As a validity check on the model represented by equation 2-2, one can compare the coefficients of the dependent variables *lnBV* and *E*/BV* obtained from the regressions with expected values. The *lnBV* value is expected to be unity: an incremental increase in book value should be reflected as the same increment in market value. The significance of earnings in traditional valuation methods (for example, the discounted cash flow model (Firer, Ross, Westerfield and Jordan, 2009)) leads to the expectation that the coefficient of *E*/BV* will be large and positive.

In their initial regressions, Johnson and Pazderka (1993) obtain *lnBV* coefficients which were statistically indistinguishable from unity. Their coefficients for *E*/BV*, however, were small and sometimes negative. After examining the data, Johnson and Pazderka (1993) found that a few outliers involving companies with large negative abnormal earnings were skewing the results. After excluding cases with negative earnings, the authors' results for all three datasets showed the expected result that *E*/BV* was a significant determinant of market value. Also, in all three regressions the coefficients of the R&D variable (*RD/BV*) were significant (at the 5% level) and positive – values varied over a fairly narrow range from 1.3 to 1.8. Coefficients for the investment term were small, and varied from negative to positive. Finally, Johnson and Pazderka (1993) pooled the data for the three periods to create a larger, but unbalanced dataset. The regression results on this dataset were similar to those obtained on the three balanced sets.

The Johnson and Pazderka (1993) study involved data from a variety of Canadian industries. The authors made an attempt to identify differences in the results across industries, but the dataset was too small to draw reliable conclusions.

Johnson and Pazderka (1993) conclude that the consistency of their results across various datasets, together with the qualitative similarity of their results to those of Ben-Zion (1984) indicate that the model described by equation 2-2 is robust and provides a reliable indication of the impact of R&D investment on the market value of companies. The authors conclude that the Canadian market is not myopic in terms of R&D investment, and factors innovative activity into the valuation of companies.

In a more recent study, Ali Shah, Stark, and Akbar (2008) used a similar model as described above to investigate the effect of R&D investment on the market value of UK firms. These authors include advertising expense as an explanatory variable, and use 1794 observations from pooled data covering the years 1998-2002. Given their large database of observations, Ali Shah, Stark, and Akbar (2008) were able to investigate both firm size effects, and industry sector effects. The authors find statistically significant positive valuation influences in manufacturing and non-manufacturing sub-samples, as well as in the Pharmaceuticals and Electronic Equipment sectors.

When breaking their data down into firms of small, medium, and large size, Ali Shah, Stark, and Akbar (2008) find statistically positive valuation effects in all three groupings. The coefficients of the R&D variable tends to increase with firm size (Ali Shah et al., 2008), indicating a size advantage when it comes to R&D investment. A 1993 study of US firms by Chauvin and Hirschey (1993), using a linear sum of accounting variables including R&D expenditure, reached the same general conclusions regarding a positive influence of R&D expenditure on the market's valuation of the firm.

Other researchers have used a Tobin's q approach to develop the theoretical framework for empirical studies of the determinants of the market value of companies (Bosworth and Rogers, 2001), (Griliches, 1984), (Hall, 1993). Tobin's q is the ratio of market value of the firm to the replacement cost of its assets. Bosworth and Rogers (2001) investigated the market valuation of R&D investment for a sample of 60 listed Australian companies, and concluded that R&D investment had a positive effect on the market value of companies. These authors, however, report lower values of the R&D coefficient than those obtained in US and UK studies, and suggest that R&D is undervalued in Australia. Hall (1993) used the Tobin's q approach to show that the market value of R&D capital in the US manufacturing sector decreased significantly during the 1980's.

The literature shows that cross-sectional regression analyses of various forms, and on samples from a range of economies, give qualitatively consistent results, indicating that the method is robust and provides reliable estimates of the various factors which influence the market values of companies. In general, a positive correlation exists between R&D intensity and market value. The coefficient of the R&D variable, which can be interpreted as the return on R&D to the company shareholders, varies across studies, which might indicate differences between countries. Also, the coefficient does show sector and firm size dependencies.

2.5 South African Context

Few empirical studies on the market's valuation of R&D investments have been carried out in the South African economy. In response to concerns that developing economies, including South Africa, under-invest in R&D, Bhana (2001) carried out an empirical study using companies listed on the Johannesburg Stock Exchange (JSE). The author used an event based methodology to investigate the stock prices of companies following unexpected announcements of increases in R&D spending. The method is therefore of the "new news" category described in section 2.3.

Bhana (2001) identified 151 announcements made by JSE listed companies in the period 1980 – 1997. In that paper, abnormal returns for each company in the period preceding and following the announcement were computed using the capital asset pricing model (CAPM) approach:

$$AR_{it} = R_{it} - (\alpha_i + \beta_i R_{mt}).$$

The index *t* refers to the day relative to the announcement, *t*=0 being the day of the announcement. AR_{it} is the abnormal return of company *i* on day *t*, R_{it} is the return for company *i* on day *t*, and R_{mt} is overall market return on day *t*. α and β are the usual CAPM parameters, estimated based on a long term regression of the company returns with the overall JSE index returns.

Bhana (2001) computed the average abnormal returns for the sample of 151 announcements, and then cumulated these for the 15 days preceding the announcement, for the 2 days of the announcement and the following day (*t*= 0,1) and for the 15 days following the announcement. The author's results show a statistically significant (at the 1% level) increase in abnormal returns for the period of the announcement (*t*=0,1). Bhana (2001) carried out a similar analysis of counterpart companies over the same period. Counterparts were companies identified as operating in the same market as the announcing company. These showed a statistically significant (at the 5% level) drop in abnormal returns in the announcement period.

According to Bhana (2001,35) "the findings strongly indicate that the announcement of a plan to increase R&D expenditures results in a simultaneous upward revision in the investor's assessment of the market value of the announcing firm and a downward revision in their assessment of the market value of counterparts."

Bhana (2001) concludes that the JSE recognises the value of R&D investments, and that managers are therefore not incentivised to under-invest in R&D to maximise short term profit. "The market appears to capitalise R&D expenditures, despite their accounting treatment in which such expenditures are mainly expensed as incurred" (Bhana, 2001,38-39).

2.6 Conclusion of Literature Review, and Research Hypothesis

In conclusion, the literature reviewed here yields a consistent picture that the market is not myopic to R&D investment. The methodologies employed have proved robust to various statistical tests, and consistent results have been obtained across studies within a wide range of economies. Both cross sectional and event based studies have concluded that the market, in general, reacts positively to R&D investment by companies. The current research will apply a similar approach to that of Johnson and Pazderka (1993), to test the following hypothesis:

H1: The South African stock market places a positive value on R&D investments by companies. Investors recognise the long term benefits of R&D, and do not penalise companies for making such investments.

In contrast, the null hypothesis can be stated as follows:

H0: The South African stock market does not recognise the value of R&D investments when determining share prices of listed companies.

3 RESEARCH METHODOLOGY

3.1 Introduction

The literature reviewed in section 2.4 uses a cross sectional methodology to determine the impact of R&D investments on the market's valuation of companies. Linear models, with market value as the dependent variable, and various explanatory variables including R&D stock or flow variables are used in a multiple linear regression analysis. The aim is to extract the coefficient of the R&D variable, which can be interpreted as the return to shareholders of R&D investment.

The method differs from many approaches to assessing R&D impact, in that the focus is on the market's current valuation of the future benefits of R&D. In contrast, qualitative case study methods, or methods which try to determine the effect of R&D on productivity, or profitability, require detailed information on the long term outcomes of R&D projects. As discussed in section 2.1, such methods are time consuming and are often biased by using high profile or successful cases (Johnson and Pazderka, 1993). Quantitative methods, based on market value, do not suffer from such drawbacks. In addition, the outcome provides an indication of the overall market view on R&D activity, rather than attempting to establish the specific long term outcomes of R&D programmes.

The research design will be described in detail in the next section. This will include the specification of the linear model, and definitions of the dependent and independent variables. Details of the sources of data and how the data are extracted from financial reports will be given in section 3.3. Sections 3.4 and 3.5 will address the limitations and validity of the approach, respectively.

3.2 Research Design

The approach of Johnson and Pazderka (1993), who carried out a study of the Canadian market, will be replicated in the South African market. This is a cross sectional study, using data from a sample of companies in multiple financial periods.

The method involves applying multiple linear regression (Evans, 2010) using the linear model given by equation 2-2:

$$lnMV = \beta_0 + \beta_1 lnBV + \beta_2 \frac{E^*}{BV} + \beta_3 \frac{RD}{BV} + \beta_4 \frac{INV}{BV}. \tag{3-1}$$

The dependent variable and four independent variables are defined in Table 1. Since we are interested in the investor's valuation of the company, book value is taken as the value of equity attributable to ordinary shareholders. For the same reason, income attributable to ordinary shareholders is used in the abnormal earnings calculation.

It is important to note that Johnson and Pazderka (1993) had to exclude negative E^* cases in order to obtain a sensible value of the abnormal earnings coefficient. Examination of the model 3-1 suggests the following explanation. Negative values of E^* would reduce the predicted market value, potentially requiring that market value be lower than book value. While some companies are valued lower than book value, this usually represents an undervaluation. In this circumstance the company could be bought, and its assets sold at a profit. In principle, a model should not allow for book value being higher than market value, and therefore it can be argued that the model does not account adequately for negative E^*. This is discussed further in chapter 4, where the results of the linear regression analysis are presented.

Standard least squares multiple linear regression (Evans, 2010) will be applied to determine the β coefficients in the regression equation 3-1. The multiple regression will be carried out using the SPSS 20.0 statistical package (IBM Corp., 2011). Of primary interest in the research is the coefficient of the R&D variable, β_3. The hypothesis H1 (see section 2.6), concerning the positive impact of R&D investment, amounts to the following hypothesis test:

$$\begin{aligned} &H0: \beta_3 = 0, \\ &H1: \beta_3 \neq 0. \end{aligned} \tag{3-2}$$

The null hypothesis corresponds to the case where R&D investment has no significant effect on market value. Hypothesis H1 in equation 3-2 includes the cases where R&D has either a positive ($\beta_3 > 0$), or a detrimental ($\beta_3 < 0$) effect on market value. Standard regression statistics (Evans, 2010) will be applied to determine the significance of the result at a 5% significance level.

Table 1: Definition of dependent and independent variables used in the linear regression analysis.

	Variable name	Definition	Source
Dependent Variable	*lnMV*	Logarithm of market value	Calculated as share price at the end of the period, multiplied by shares outstanding.
Independent Variables	*lnBV*	Logarithm of book value	Total value of the equity attributable to ordinary shareholders, as reported on the balance sheet.
	E/BV*	Abnormal earnings relative to book value	$E^* = NI - kBV$, where *NI* is net income attributable to ordinary shareholders, from the income statement, and *k* is the cost-of-capital.
	RD/BV	R&D investment for the period, relative to book value	Following Johnson and Pazderka (1993), the reported R&D expenditure for the period, or flow variable, is used.
	INV/BV	Net investment of the firm for the period, relative to book value.	Taken from the cash flow statement, this variable controls for the general effect of investment on market value.

Given the low percentage of revenues invested in R&D by South African companies, the power of the test is of concern. In other words, what is the probability that the null hypothesis will be incorrectly accepted by the test, given the expectation that the R&D effect on market value is small? The power of the test has been analysed *a-priori* using the PASS 11 statistical package (Hintze, 2011). The analysis requires the sample size N, the significance level α, the number of independent variables to be tested, and the number of independent control variables. For the analysis we assume a sample size of 50, and a significance level of 5%. In the model equation 3-1 we have one independent variable to be tested (*RD/BV*), and 3 control variables (*lnBV*, *E*/BV*, and *INV/BV*).

Table 2: PASS 11 report for the *a-priori* power analysis of the regression with respect to the R&D variable being tested. A range of expected R^2 values attributed to the R&D variable, from 1% to 5%, is used.

				Ind. Variables Tested		Ind. Variables Controlled	
Power	**N**	**Alpha**	**Beta**	**Cnt**	**R2**	**Cnt**	**R2**
0.35501	50	0.05000	0.64499	1	0.01	3	0.80
0.63554	50	0.05000	0.36446	1	0.02	3	0.80
0.82806	50	0.05000	0.17194	1	0.03	3	0.80
0.93308	50	0.05000	0.06692	1	0.04	3	0.80
0.97902	50	0.05000	0.02098	1	0.05	3	0.80

Report Definitions
Power is the probability of rejecting a false null hypothesis.
N is the number of observations on which the multiple regression is computed.
Alpha is the probability of rejecting a true null hypothesis. It should be small.
Beta is the probability of accepting a false null hypothesis. It should be small.
Cnt refers to the number of independent variables in that category.
R2 is the amount that is added to the overall R-Squared value by these variables.
Ind. Variables Tested are those variables whose regression coefficients are tested against zero.
Ind. Variables Controlled are those variables whose influence is removed from experimental error.

Summary Statements
A sample size of 50 achieves 98% power to detect an R-Squared of 0.05 attributed to 1 independent variable(s) using an F-Test with a significance level (alpha) of 0.05000. The variables tested are adjusted for an additional 3 independent variable(s) with an R-Squared of 0.80.

The *a-priori* power analysis also requires estimates of the extent to which each of the variables explain the variance in the data. In other words, estimates of the R^2 value attributable to each variable are required. The literature typically reports high R^2 values for models of the type used in this research. Johnson and Pazderke (1993), for example, obtain $R^2 = 0.949$ on their pooled, unbalanced dataset. As discussed in the literature review (section 2.4), book value and abnormal earnings are expected to be significant determinants of market value. For the power analysis, we therefore estimate the contribution of the three control variables to R^2 to be 80%. The analysis is run for a range of contributions of the R&D variable from 1% to 5%.

The PASS 11 report is given in Table 2. The report indicates that, for 50 observations, there is a high probability (65%) of accepting the null hypothesis for an R^2 value of 1%. This probability drops to 2% when the R&D variable has an R^2 of 5%. In conclusion, the power analysis indicates that the test has a high probability of detecting the effects of the R&D variable if it contributes 3% or more to R^2.

3.3 Data and Data Source

3.3.1 *Introduction*

The data includes all JSE listed companies for the five financial periods ending July 2012. Due to the anticipated difficulty in obtaining data, observations will not be constrained to any specific sector. The approach will be to obtain as many observations as possible, with the aim to obtain a preliminary indication as to the extent to which R&D investments are valued by investors.

Financial services companies will be excluded from the analysis. This exclusion is based on two points. Firstly, the valuation of banks and other financial services companies is notoriously difficult, and the model used in the current research may not be appropriate. Secondly, the financial services industry is less likely to engage in R&D activity as defined in this research. This assumption is born out in the data as discussed in chapter 4.

The linear regression model 3-1 will be applied to all companies in the population, as well as to the subset of that population which reports R&D expenses. The purpose of the former is to investigate the non-R&D independent variables across a larger dataset.

As discussed in section 2.4, Johnson and Pazderka (1993) used panels of data, involving a number of companies reporting R&D spending over consecutive years. These authors identified three periods in which 52, 54, and 47 companies provided consecutive R&D data. Pooling these data led to three balanced datasets of 156, 162, and 188 observations, respectively. Three regressions were carried out, using all of the observations in each data panel. The datasets were balanced in the sense that the sample included the same number of periods of observation for each company, and that these periods were consecutive. The authors found, however, that pooling all three sets into an unbalanced dataset did not significantly change the results (Johnson and Pazderka, 1993).

The current research will attempt as far as possible to follow a similar approach. The strict requirement that the dataset be balanced, and drawn from consecutive financial periods, may restrict the size of the dataset too severely. The aim will be to obtain of the order 100 observations, while ensuring there are no severe imbalances. The observation by Johnson and Pazderka (1993) that the requirement that the data panels be balanced is not critical, supports this approach.

3.3.2 *Regression Variables*

The McGregor BFA database (McGregor BFA, 2012a) contains financial statements for all listed companies, captured in a standard form. This allows for the line items required for the independent variables listed in Table 1 to be extracted for all companies over the period of in interest. Specifically, McGregor BFA (McGregor BFA, 2012a) includes reported R&D expenses in the income statement.

Data have been acquired for all JSE listed companies covering the most recent five reporting periods. For companies reporting early in 2012, this includes the 2012 – 2008 financial periods. For the rest, the 2011 – 2007 reporting periods are used. For market value, the monthly share price data for 2007 to 2012 were downloaded from the I-Net Bridge database (I-Net Bridge, 2012). These data were used to determine the market value, and to calculate the β values. The independent variables in the model equation 3-1 were obtained from the published financial statements. For these, a report containing the balance sheet, balance sheet supplementary data, income statement, and cash flow statements was generated from the McGregor BFA database (McGregor BFA, 2012a). Each variable is discussed in detail below.

a. *Market Value*

The logarithm of the market value (*MV*) is the dependent variable in the model. The market value for each observation is calculated from the close price of the share in the reporting month, for each company in each of the 5 year periods. This is multiplied by the number of ordinary shares outstanding, obtained from the balance sheet supplementary data (from the McGregor BFA report (McGregor BFA, 2012a)).

b. ***Book Value***

The first independent variable is the logarithm of book value (*BV*). As discussed in section 3.2, the book value of interest is the value of equity attributable to ordinary shareholders. These values are obtained from the balance sheet in the McGregor BFA report (McGregor BFA, 2012a). Note that some companies report in currencies other than ZAR. In these cases values were converted to ZAR by using the close exchange rate in the reporting month. Exchange rates were obtained from the McGregor BFA database (McGregor BFA, 2012b).

c. ***Abnormal Earnings***

The second independent variable is the abnormal earnings of the company, for the period, normalised to book value. Abnormal earnings represent earnings beyond cost-of-capital. Abnormal earnings are denoted E^*, and is calculated from the net income NI on the income statement, $E^* = NI – kBV.$ To remain consistent with the analysis in terms value to ordinary shareholders, the profit attributable to ordinary shareholders, after interest and tax, is used. This is obtained from the McGregor BFA income statement report (McGregor BFA, 2012a). The cost-of-capital, according to the CAPM model, is given by $k = R_f + \beta M_p$. For this calculation, a risk free rate R_f of 7% and market premium M_p of 5% is used (Cilliers AJ, 2005). The levered β values are determined from the monthly share price data. The share return is plotted against overall market return, with β given by the slope coefficient from a linear regression of the data.

d. ***R&D***

The third independent variable in the model is the research and development expense *RD*, obtained from the McGregor BFA income statement report (McGregor BFA, 2012a). This is also normalised to book value.

e. ***Net Investment***

The final independent variable in the model is net investment *INV*, normalised to book value. This is the cash outflow from investment activities, in the cash flow statement (McGregor BFA, 2012a).

3.4 Limitations of the study

The following limitations of the current research are identified:

- The study is constrained to listed companies, due to the requirement for detailed financial information, and of course due to the need for an accurate market value. Small start-ups are therefore excluded from the study. R&D makes up a significant part of the investments made by small high tech start-ups. The study therefore does not include this important sector in the innovation landscape.
- The study will not attempt to compare results across different sectors and industries. The aim of this research is to determine the extent to which R&D investment is valued by the market, in general.
- The study will not attempt to investigate differences across other variables, such as firm size, market position, etc.

3.5 Validity and reliability

The validity of the research refers to the extent which the instrument and methodology address the research questions and propositions (Kumar, 2005). Reliability refers to the extent to which the result is repeatable (Kumar, 2005). In other words, would another researcher have reached the same conclusion?

3.5.1 *External validity*

External validity refers to the extent to which the research results apply outside the sample, industries, or geographical regions in which the research was carried out (Gravetter and Forzano, 2009). External validity may be compromised by the presence of several variables that are specific to the context in which the research is carried, making it difficult to extrapolate the result to other situations. The current research does involve such complexity, and therefore extrapolation outside of South Africa should be done with caution.

3.5.2 *Internal validity*

Internal validity refers to the extent to which the methodology is valid within the sample space used (Gravetter and Forzano, 2009). The proposed regression analysis, using the appropriate statistical tests, will assure validity within the population under study. The market value model used, and variations thereof, has been applied successfully in several studies in a range of economies. The consistent results reported in the literature (see section 2.4) demonstrate the robustness of the model.

A possible concern over the validity of the model for companies with negative abnormal earnings has been raised in section 3.2. This effect has been observed in the present study, and will be discussed further in chapter 4.3. A further concern relates to the effect of capitalisation of R&D expenditures. Such capitalisation is sometimes done when the output of R&D has a definite and probable financial benefit, and previous R&D costs are transferred to the balance sheet as intangible assets. The principle behind the current model, however, is that the current period flow variable (R&D expenses) is used as a proxy for the stock of R&D intangibles, and therefore as a proxy of innovative activity. It is therefore expected that this variable will be significant if the market recognises the value of such activity.

3.5.3 *Reliability*

The reliability of the result will depend on the extent to which the sample represents the population under study. As discussed in section 3.2 an attempt will be made to include all companies reporting R&D expenditure for the period under consideration. Since there is no ambiguity in the definition of the variables used in the regression analysis, repeatability of the result is insured.

4 PRESENTATION OF RESULTS

4.1 Introduction

This chapter provides descriptive statistics on the panel data required by the linear regression model equation 3-1. The data are discussed in terms of sample size and validity. The focus is on the generation of a balanced set of panel data to which the model can be applied. The database generated is for all JSE listed companies, excluding financial services, irrespective of whether R&D expenses are reported or not. The subset of companies reporting R&D is then extracted. Regression analysis is performed on both sets of data. The chapter includes a discussion of the South African R&D landscape, based on trends and features observed in the data. Finally, the results of the linear regression analysis are presented.

4.2 Descriptive Statistics

4.2.1 *The Panel Dataset*

The data collection procedure resulted in a dataset for all JSE listed companies (financial services excluded) over the past 5 financial periods, and contains 1186 observations. This represents approximately 236 companies. The fact that the total number of observations is not a multiple of 5 is due to the following. Firstly, not all companies were listed over the full 5 year period. Secondly, it was found that missing data in the I-Net Bridge (I-Net Bridge, 2012) and McGregor BFA database (McGregor BFA, 2012b) meant that not all observations could be used. Specifically, price data were missing for certain companies in certain years. The latter affected about 1% of the observations.

Of these 1186 observations, 263 included reported R&D expenses. Including financial services increases this to 277 observations. The annual total number of companies reporting R&D, together with the total expense, is given in Table 3. Approximately 60 companies report R&D each year. Note that the lower numbers in 2012 and 2007 are an artefact, as these only include companies reporting in the first 6 months of 2012, and the last 6 months of 2007.

The dataset of 1186 is not a balanced panel dataset, since there are not 5 observations for each company. Strictly, only companies for which all five observations are available should be retained. It was found that this requirement would have severely limited the final dataset in which R&D reporting companies were extracted. It was decided to retain companies for which at least four observations were available over the 5 year period. This reduced the dataset to 1114 observations.

From this dataset, only those reporting R&D expenses were extracted. Once again applying the condition that only companies with at least 4 observations be retained, led to a database of R&D reporting companies of 199 observations. These reduced datasets of 1114 companies, of which 199 report R&D expenses, will be referred to as the *Balanced* and *Balanced (R&D reported)* panel datasets, respectively.

Table 3. Annual total reported R&D expense, together with the number of companies reporting in each year. The lower numbers in 2012 and 2007 are due to the fact that they only include companies reporting in the first six months of 2012, and last six months of 2007.

Year	Total R&D expense (R 000)	No. of companies
2012	2,809,102	19
2011	4,820,706	58
2010	3,658,218	59
2009	4,913,417	62
2008	5,202,341	55
2007	1,123,214	23

The data include the entire population of non-financial JSE companies. Exclusions were based only on missing data (approximately 1%), and by the condition that at least 4 observations per company are available over the 5 year period. The latter condition led to the exclusion of a further 6% of the observations. The datasets are therefore highly representative of the entire population.

A possible concern is that companies hide losses by attributing them to R&D expense, when in fact the expense does not represent legitimate R&D. Modern

GAAP reporting standards reduce the chance of this happening. In addition, the condition that only companies with at least 4 observations be included means that only companies consistently reporting R&D are considered. Based on this, it is unlikely that illegitimate R&D reporting will have a significant effect on the analysis presented here.

4.2.2 *The Market to Book Value Multiple*

The basis of the regression model equation 3-1 is that the market value is made up of the sum of tangible (book value) and intangible assets. The purpose of the research is to investigate the significance of intangible assets such as R&D capital in accounting for the valuation of the company over and above book value. Table 4 shows the mean and median values of *MV/BV* for the two balanced datasets. Outliers, for which *MV/BV* is 5 standard deviations from the mean, are excluded.

The mean value of the multiple lies close to 2 in each dataset, meaning that on average the companies are valued at twice the book value. The standard deviations are large, indicating a wide range of market valuations with respect to book value. The median values are lower, indicating that the data are skewed, with the mean driven up by a few companies with high *MV/BV* multiples.

Table 4. Market Value to Book Value multiples for the two balanced datasets. Mean, median, and standard deviations are given for the *Balanced* (1114 observations) and *Balanced (R&D reported)* (199 observations) datasets. Outliers have been excluded.

	MV/BV (Balanced)	*MV/BV* (Balanced R&D reported)
Mean	1.90	2.19
Median	1.41	1.94
Std dev.	1.68	1.57

4.2.3 *The South African R&D Landscape*

The trends in, and distribution of, R&D spend by JSE listed companies, are analysed in this section. As mentioned above, approximately 60 companies reported R&D expenses each year over the period 2008 – 2011. The annual R&D spend and number of companies reporting are summarised in Figure 1. We observe a significant minimum in 2010, which may represent reduced spending due to restructuring in response to the onset of the financial crisis during 2008. It is interesting to note that R&D spend has recovered to almost pre-crisis levels by 2011.

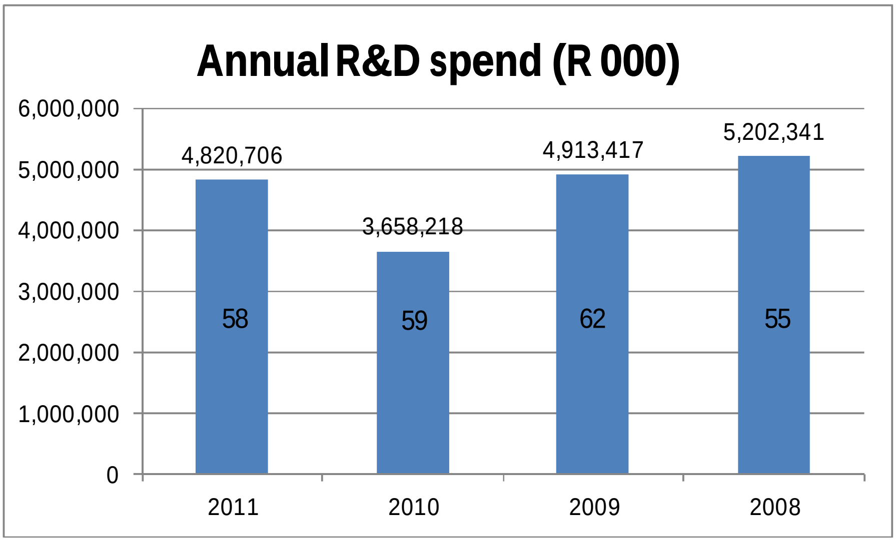

Figure 1. Annualised total R&D spend by JSE listed companies for the period 2008 – 2011. The total number of companies reporting in each year is indicated on the graph.

The data of Figure 1 show an annual spend by JSE listed companies of approximately R5bn. This represents 25% of the total spend in the South African economy, as determined in the 2008/2009 survey (Blankley, 2011). According to the survey, South Africa spent R21bn on R&D in the 2008/2009 period. The business sector accounted for the majority of R&D spend at 58.6%. Higher education centres and science councils contributed 20% and 15%, respectively (Blankley, 2011). This would suggest that the unlisted business sector spent approximately R8bn on R&D during the period of the survey. It should be noted, however, that not all of the R5bn attributed to JSE listed companies can also be attributed to South African R&D activity. As will be discussed below, a large portion of R&D spend is by dual listed multinationals, a portion of whose R&D is carried out outside the borders of South Africa.

The sectorial breakdown for companies reporting in 2011 is given in Table 5. Sector definitions used here follow those used by the McGregor BFA database (McGregor

BFA, 2012a). The breakdown is also summarised graphically in Figure 2. Three sectors clearly dominate: Basic Materials, Consumer Goods, and Oil and Gas. This is in contrast to the traditional R&D intensive sectors observed in developed countries, where high tech industries such as pharmaceuticals, technology, and communications tend to have the highest R&D intensity (see, for example, (Grueber and Studt, 2010)).

A clear feature of South African R&D is the extent to which it is concentrated. All R&D in the Oil and Gas sector is attributed to Sasol. Their R1bn R&D expense, furthermore, accounts for 20% of the total R&D spend reported by JSE listed companies in 2011. The concentration of R&D intensity is illustrated in the cumulative plot shown in Figure 3. 80% of total R&D by Rand value for 2011 is spent by just 10 companies. The top 3 R&D spenders in 2011 are:

- British American Tobacco (Consumer Goods) : 22%
- Sasol Ltd. (Oil and Gas): 21%
- BHP Billiton Plc. (Basic Materials): 10%

Table 5. Sectorial breakdown of R&D spend by JSE listed companies for the year 2011. Sector definitions follow those of the McGregor BFA database (McGregor BFA, 2012a).

Sector	Sector Label	R&D spend (R 000)	Number of companies
Basic Materials	1	1,638,389	14
Industrials	2	227,325	19
Technology	3	30,637	4
Telecoms	4	77,000	1
Health Care	5	86,751	3
Oil and Gas	6	1,006,000	1
Consumer Goods	7	1,577,015	10
Consumer Services	8	62,807	2
Financial Services	9	114,782	4
Utilities	10	0	0
Total		**4,820,706**	**58**

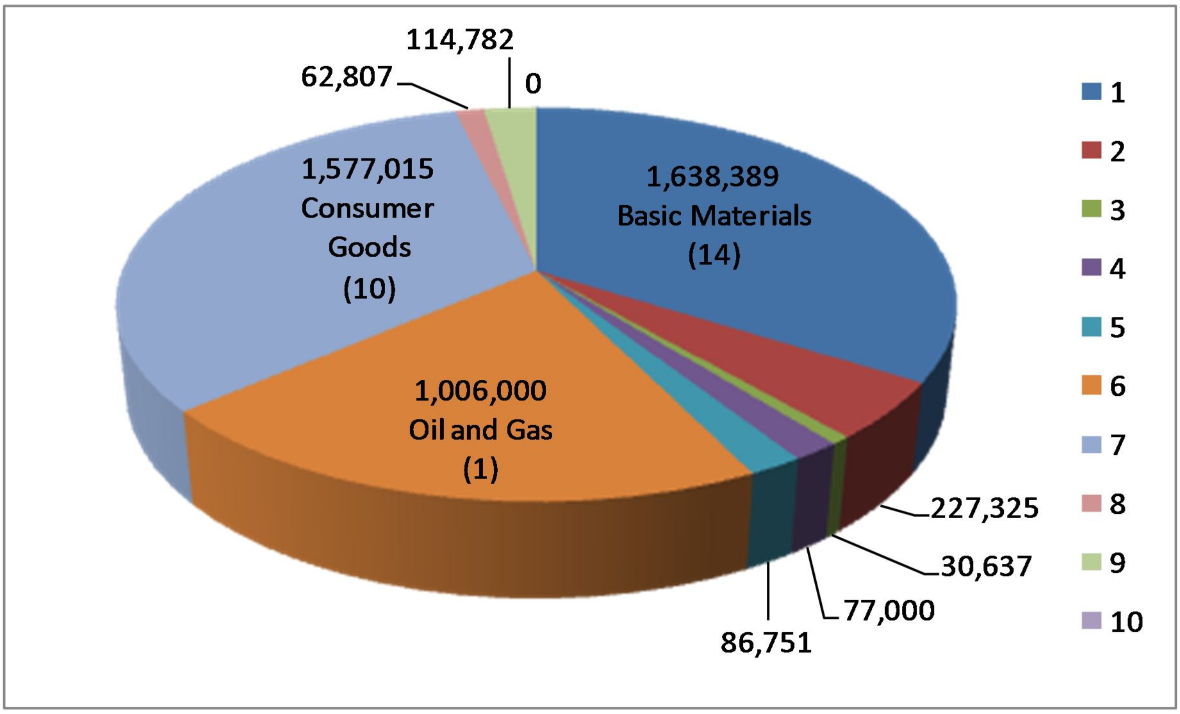

Figure 2. Graphic of the sectorial breakdown of R&D spend for 2011. The sector labels are as given in Table 5. Totals (R 000) and number of companies reporting (bracketed number) are shown for the three major contributors.

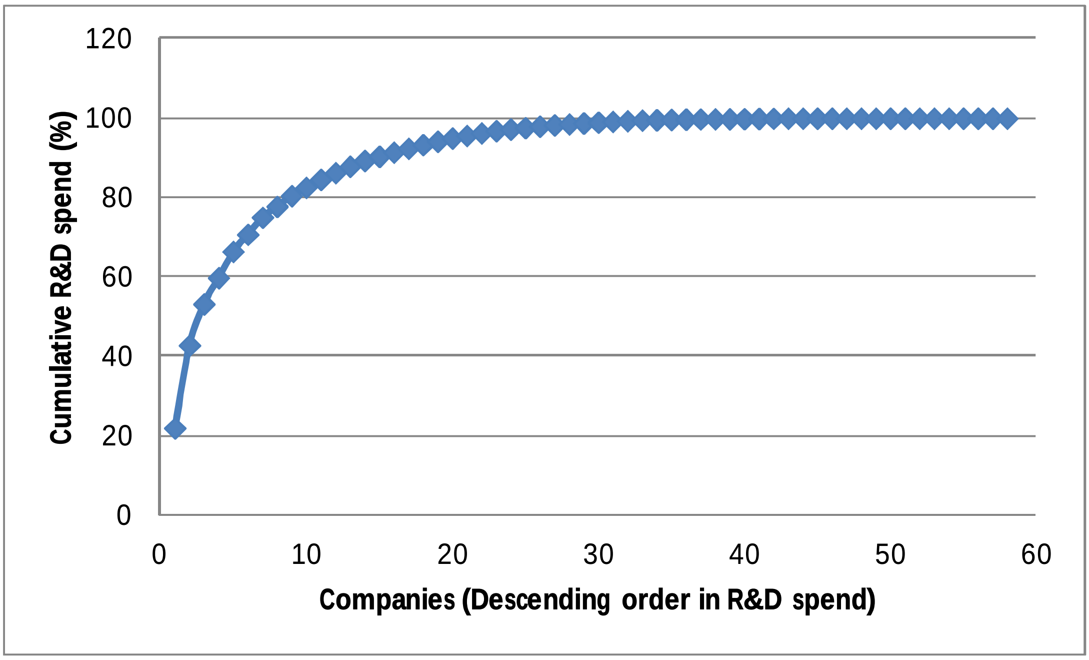

Figure 3. Cumulative R&D spend by the 58 reporting companies in 2011. The companies are ordered on the x-axis according to decreasing R&D spend.

In conclusion, it is noted that R&D is dominated by the resource sectors (Basic Materials and Oil & Gas). This is not surprising due the fact that South Africa is a resource rich country, and that a large percentage of capital is invested in these sectors. As a developing country, it does not come as a surprise that R&D intensity in high tech industries is low. South Africa depends on imports for most of its information and telecommunications technologies.

It is further noted that R&D by JSE listed companies is highly concentrated, with a few large multinationals accounting for a large fraction of R&D spend. The effect of this is that most companies included in the cross sectional analysis that is presented in the next section contribute a small fraction to overall R&D spend on the JSE. The logarithmic form of equation 3-1, however, means that the data are size normalised, and so this does not, in principle, affect the result.

4.3 Linear Regression Results

4.3.1 *Model Summary and Regression Coefficients*

The regression model 3-1 has been applied to four sets of data (see Table 6). The first regression R1 was applied to the balanced dataset, which includes all cases, irrespective of whether R&D expenses were reported or not. R2 refers to the subset of the balanced dataset in which negative *E** cases are excluded. The regression R3 was carried out on the subset of the balanced dataset which excluded those for which no R&D expense was reported. Finally, R4 included only those observations for which R&D was reported, and for which *E** was positive. Table 6 summarises the regression results.

The explanatory power, or R^2, of the model is high (better than 80%) in all four cases. R4 has the highest R^2 value (0.958). In all four cases the coefficient of the book value term β_1 is significant (at the 5% level) and close to unity. This is expected: a one rand increase in book value is expected to result in one rand increase in market value. The fact that a logically consistent value of β_1 is obtained gives us confidence in the credibility of the model. As discussed in section 2.4, the reviewed literature reports similar results.

The coefficient β_2 of the abnormal earnings term also provides a sanity check on the model. As discussed in section 2.4, the abnormal earnings provide a proxy of the long term profitability of the company, and so they are expected to be a highly significant determinant of market value. For regressions R2 and R4, which exclude cases with negative abnormal earnings, we obtain β_2 coefficients close to a value of 2, and which are significant at the 5% level. In the case of regressions R1 and R3, which include negative abnormal earnings cases, the β_2 are significant (5% level) but small. For R1 in particular, a negative value of -0.069 is obtained. For R3 β_2 is positive, and slightly less than unity. A similar observation was made by Johnson and Pazderka (1993), who found that by excluding negative abnormal earnings they were able to obtain sensible regression coefficients (see section 2.4). As suggested in section 3.2, this possibly represents a limitation of the model. Negative abnormal earnings should not erode book value, and the model does not adequately allow for this. Since negative abnormal earnings cases account for 40% of the balanced dataset (used in R1), and 30% of the subset which report R&D expenses (used in R3), this is expected to have a significant effect on the results.

Table 6. Summary of regression results for the four datasets.

$lnMV = \beta_0 + \beta_1 lnBV + \beta_2 \frac{E^*}{BV} + \beta_3 \frac{RD}{BV} + \beta_4 \frac{INV}{BV}$				
Regression	Data	No. of cases	R^2 (adj. R^2)	Coefficients (t-statistic)
R1	Balanced dataset	1114	0.848	β_0 = -0.387* (-2.089) β_1 = 1.060* (78.201) β_2 = -0.069* (-8.103) β_3 = 0.883 (0.806) β_4 = 0.025* (2.333)
R2	Balanced dataset, negative *E** excluded	670	0.910	β0 = -0.995* (-5.265) β1 = 1.099* (81.161) β2 = 1.755* (11.834) β3 = 1.686 (0.997) β4 = 0.022 (0.325)
R3	Balanced dataset (R&D reported)	199	0.940	β0 = -0.336 (-0.994) β1 = 1.047* (48.742) β2 = 0.983* (6.327) β3 = 1.413 (1.553) β4 = 0.893* (4.065)
R4	Balanced dataset (R&D reported), negative *E** excluded	135	0.958 (0.957)	β_0 = -0.614 (-1.778) β_1 = 1.072* (50.739) β_2 = 1.903* (8.775) β_3 = 0.939 (0.640) β_4 = 0.218 (1.020)

(* significant at the 5% level)

Turning attention to the coefficient β_4 of the net investment variable, we observe that it is significant only in regressions R1 and R3. In the case of R1, a small value (0.025) is obtained. In the case of R3, the result $\beta_4 = 0.893$ suggests that net investment does play a role in determining market value. This inconsistency, together with the concern that the model does not hold for negative E^* cases, suggests that this result does not provide a reliable measure of the importance of the net investment term. The reliability of the result will be discussed further with respect to multicolinearity considerations below (see section 4.3.3). In both R2 and R4, which exclude negative E^* cases, the net investment term is found to be insignificant (5% level).

The coefficient β_3 of the R&D term is of primary interest in the present research. In all four regressions the R&D term is found to be insignificant at the 5% level. In R4, for example, a significance value of 0.523 is obtained. This indicates that the term is insignificant at any reasonable level, and therefore plays no role in predicting market value. This result is discussed in further detail in the next chapter.

4.3.2 *Residual Analysis*

A residual analysis has been carried out to test the normality, linearity, and homoscedasticity of the data. The figures presented in this section are from the standard outputs of the SPSS 20.0 software.

Figure 4 shows the residual histograms for all four regressions. In all cases residuals are normally distributed about zero. Apart from some negative residual outliers in R2, the condition of normality appears to hold.

Figure 5 shows the residual scatter plots for all regressions. These plots show no evidence for non-linearity in the data, as the data are scattered about zero for the full range of predicted values. There is also no evidence of heteroscedasticity. The variance of the residuals is independent of the magnitude of the predicted value. The homoscedasticity of the data is to be expected, given the logarithmic form of the regression equation.

In conclusion, the residual analysis indicates that the linearity, homoscedasticity, and normality assumptions of regression analysis hold for all four datasets.

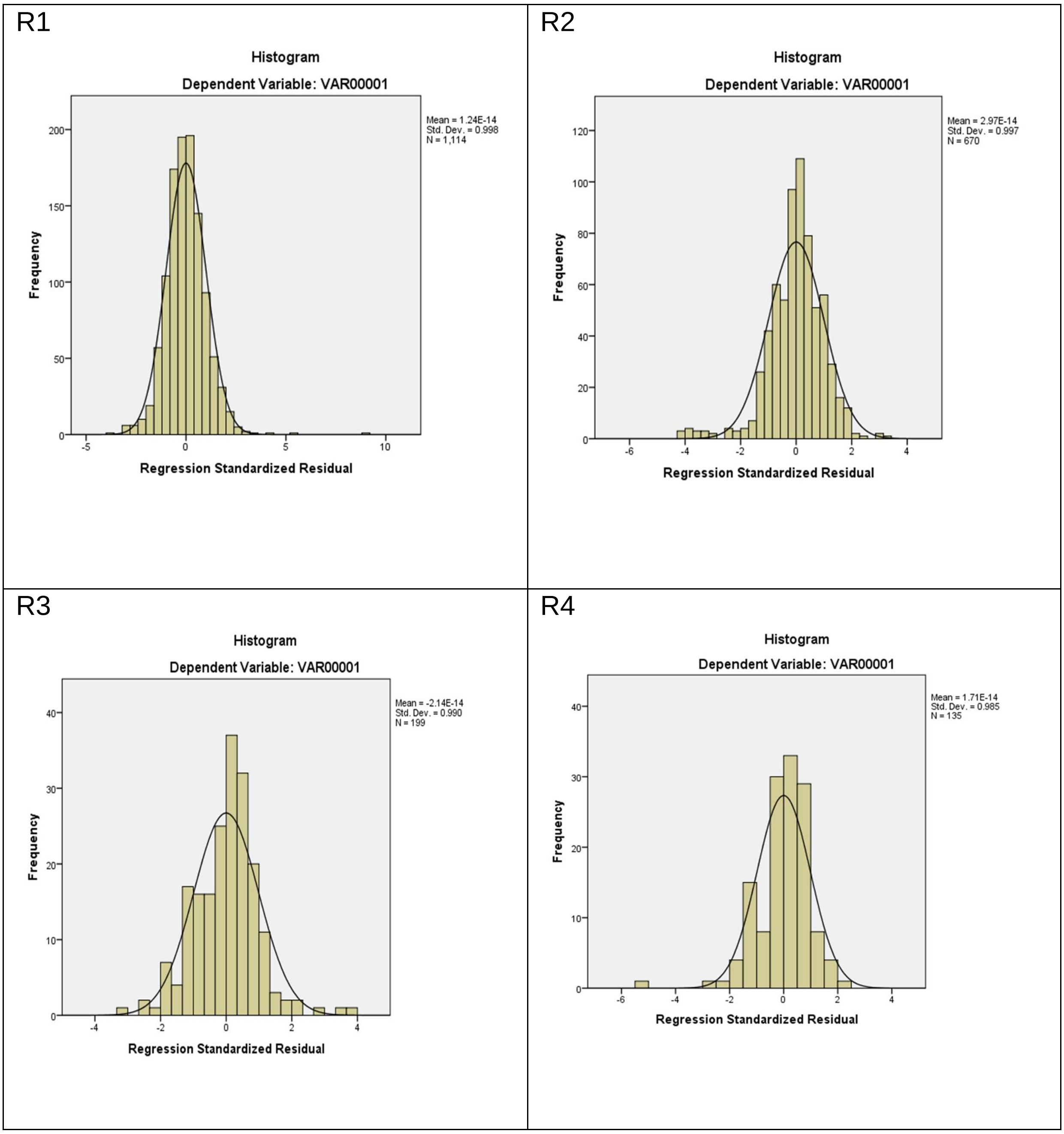

Figure 4. Histograms of standard residuals for the four regressions.

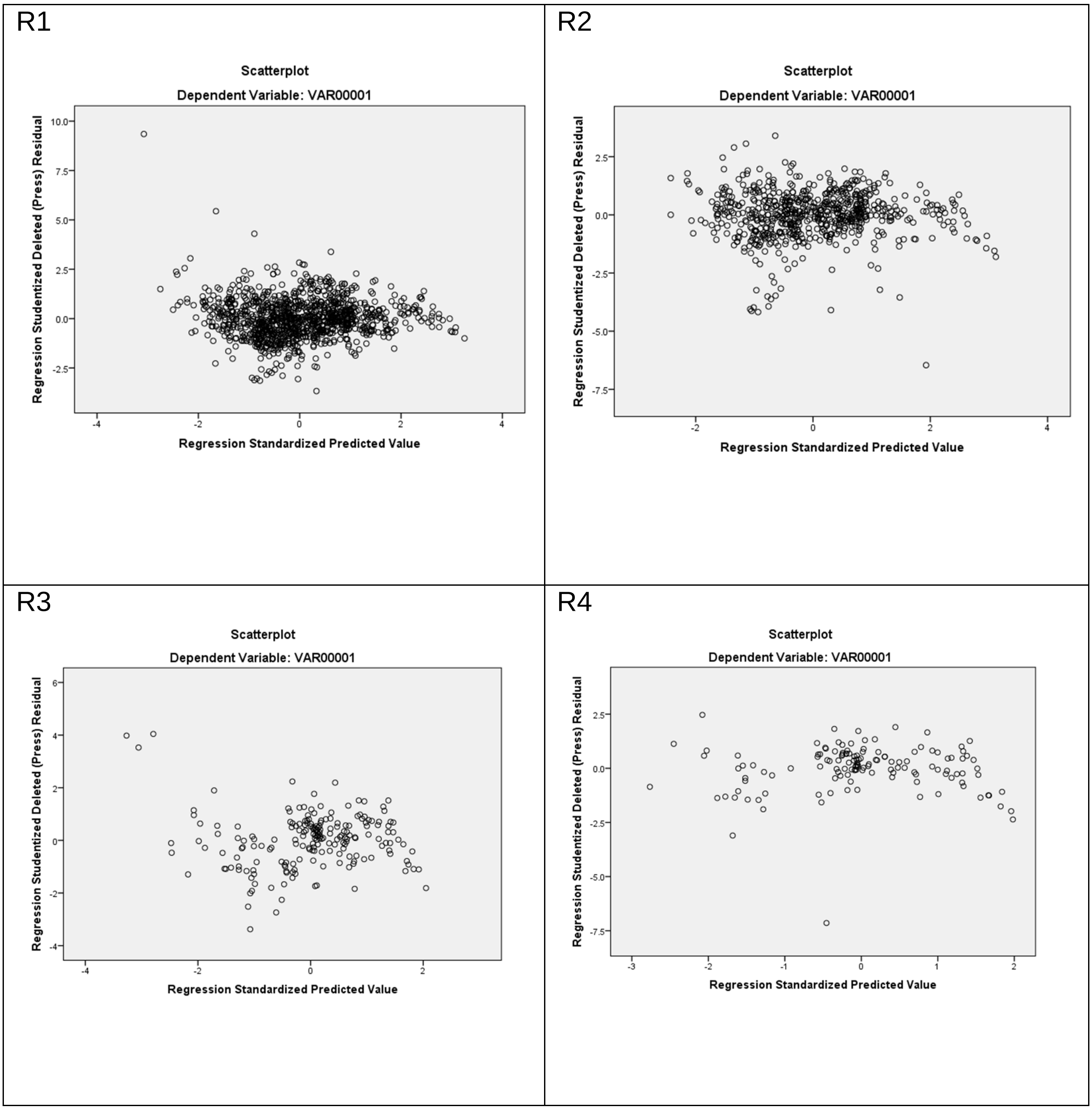

Figure 5. Residual scatterplots for the four regressions.

4.3.3 *Correlation and Multicolinearity*

The correlation matrices, as determined in SPSS 20.0, are presented in Table 7. A number of interesting correlations are observed. The most significant is the negative correlation between the investment and abnormal earnings terms, observed in all four regressions. It is the highest correlation in all but R3. This is a surprising observation, since there is no apparent reason why the investment activities of a company should accompany decreased earnings. Whatever the cause, the correlation possibly explains the instability in the coefficient of the investment term which was noted in section 4.3.1.

Table 7. Correlation matrices for the four regressions

Regression		*ln(BV)*	*E*/BV*	*RD/BV*	*INV/BV*
R1	*ln(BV)*	1.000			
	E/BV*	-0.194	1.000		
	RD/BV	0.068	-0.016	1.000	
	INV/BV	0.056	-0.563	0.005	1.000
R2	*ln(BV)*	1.000			
	E/BV*	0.012	1.000		
	RD/BV	0.042	-0.008	1.000	
	INV/BV	0.010	-0.575	0.033	1.000
R3	*ln(BV)*	1.000			
	E/BV*	-0.255	1.000		
	RD/BV	0.287	0.090	1.000	
	INV/BV	0.117	-0.179	0.042	1.000
R4	*ln(BV)*	1.000			
	E/BV*	0.089	1.000		
	RD/BV	0.366	0.029	1.000	
	INV/BV	0.063	-0.391	0.146	1.000

Regressions R1 and R3, which include negative *E** cases, show a moderate negative correlation between abnormal earnings and book value terms. This correlation disappears in R2 and R4, where negative *E** cases are excluded. Again, there is no obvious reason to expect this correlation. Further investigation would be required to ascertain whether the effect is real or arises due to outliers with large negative *E**.

Regressions R3 and R4 which exclude cases with no R&D expense show moderate positive correlations between R&D and book value terms. This could indicate that larger companies commit larger fractions of their resources to R&D. Again, this would require further detailed analysis to confirm.

In general, the analysis indicates that multicolinearity arising from highly correlated independent variables does not feature in these regressions. The only potential problem arises with the net investment term. As discussed above, this possibly explains the instability of the coefficient β_4.

4.3.4 *Regression Result with Outlier Excluded*

Regression R4 is the most pertinent to the current research question concerning the market value of R&D investments. The data only include cases for which R&D expenses are reported. Furthermore, only positive *E** cases are included, due to concerns over the model validity for negative *E** cases. The residual analysis of the previous section shows a single outlier point with a large negative residual (see Figure 4 and Figure 5). The regression has been repeated, with this point excluded. The results are presented in Table 8.

The R^2 value has increased to 0.969. Once again, the only significant independent variables are book value and abnormal earnings. The abnormal earnings coefficient has increased from 1.903 to 2.487, with a standard error of 0.202.

4.3.5 *Conclusion*

In conclusion, the residual and correlation analysis presented above supports the validity of the regression analysis presented in this chapter. Some interesting correlations between independent variables have been noted, but these require further investigation before drawing definite conclusions.

The regression model has a high explanatory power, with R^2 values in the region of 90%. In other words, approximately 90% of the variance is explained by the model. For regression R4, the model explains 97% of the variance.

The regression coefficients have been analysed in terms of logical consistency. As expected, the coefficient of the book value term is close to unity. For the datasets where negative *E** cases are excluded, a large value of the abnormal earnings coefficient is obtained. Again, this is an expected result, as earnings play a dominant role in the value of a company. In contrast, including negative *E** cases leads to the counterintuitive result that earnings do not play an important role. It has been pointed out that this highlights a limitation of the regression model.

The R&D term turns out to be insignificant, while the importance of the investment term is unclear. We can therefore not reject the null hypothesis presented in equation 3-2.

Table 8. Results of regression R4 with the single outlier case excluded.

$lnMV = \beta_0 + \beta_1 lnBV + \beta_2 \frac{E^*}{BV} + \beta_3 \frac{RD}{BV} + \beta_4 \frac{INV}{BV}$					
Regression	Data	No. of cases	R^2 (adj. R^2)	Coefficients (t-statistic)	
R4	Balanced dataset (R&D reported), negative *E** excluded	134	0.969 (0.968)	β_0 = -0.441 β_1 = 1.063* β_2 = 2.487* β_3 = 0.778 β_4 = -0.245	(-1.498) (59.030) (12.337) (0.623) (-1.269)

(* significant at the 5% level)

5 DISCUSSION AND CONCLUSION

5.1 Discussion

As discussed in the literature review, several cross-sectional studies have concluded that R&D investment has an observable and positive impact on the market value of companies. These include studies carried out in Canada (Johnson and Pazderka, 1993), USA (Ben-Zion, 1984), United Kingdom (Ali Shah et al., 2008), and Australia (Bosworth and Rogers, 2001). Direct comparison of the present results with most of these studies is complicated by differences in the functional forms used in the analysis, and different choices in independent variables.

Since the present research used the same model as in Johnson and Pazderka's Canadian study (Johnson and Pazderka, 1993), we can make a comparison with this result. The comparison is presented in Table 9, where regression R4 is compared with the pooled result of these authors. The results of regression R4 are deemed the most applicable, since they include only R&D reporting companies, and only those with positive *E**, as is the case in the Canadian study.

Table 9. Comparison of the results of the present study (regression R4) with the Canadian study by Johnson and Pazderka (1993).

Study	Country	Period	*ln(BV)*	*E*/BV*	*RD/BV*	*INV/BV*
(Johnson and Pazderka, 1993)	Canada	1985 - 1988	0.934*	1.857*	1.538*	0.080
Present study (R4)	South Africa	2007-2012	1.063*	2.487*	0.778	-0.245

(* significant at the 5% level)

The two results presented in Table 9 are very similar. Both obtain book value coefficients close to unity, and abnormal earnings coefficients close to 2. Also, both find the net investment term to be insignificant. The primary difference is that the

Canadian study finds a statistically significant R&D coefficient (1.538), whereas the present study of JSE listed companies does not result in a significant R&D term. While the value of the R&D regression coefficient is 0.778, the statistical analysis discussed in the previous chapter indicates that the result is not significant at any reasonable level. This means that the coefficient is statistically indistinguishable from zero.

The regression coefficients can be interpreted as the return to investors associated with each independent variable. The book value coefficient of unity indicates that any one rand investment in assets (plant for example) results in a one rand increase in market value. As discussed previously, this makes intuitive sense.

In the case of earnings, the coefficient of 2 means that a one rand increase in current earnings has the same impact on market value as a two rand increase in book value. (Following the interpretation of Ben-Zion (1984)). Similarly, for the Canadian study period, a one Canadian dollar increase in R&D investment has the same impact on market value as a one and a half Canadian dollar increase in book value.

The insignificance of the R&D term obtained in the present study means that the null hypothesis presented in section 2.6 cannot be rejected:

H0: The South African stock market does not recognise the value of R&D investments when determining share prices of listed companies.

Given the low values of R&D investment by South African companies, this could simply mean that the effect of R&D on company value is too small to be measured above the variance in the data, due to factors not controlled for in this study. It could also mean that South African investors do not view R&D efforts as important in generating a competitive advantage. Either way, the research indicates that R&D activity plays a minor role in the fortunes of the South African listed business sector.

The only previous study carried out on JSE listed companies, identified in the literature review, is that of Bhana (2001). The author carried out an event based study of R&D investment announcements over the period 1980-1997. Bhana (2001) observed a statistically significant increase in abnormal returns on shares in these companies, associated with R&D investment announcements. In contrast, the present research does not identify any correlation between market value and R&D activity.

The disagreement may be due to the different periods used in the two studies. The present study covers a highly volatile period which includes the financial crisis. It is possible that long term investment activity had less impact on company valuation than the more tangible factors such as book value and earnings, during this volatile and uncertain period. Another potential cause of the disagreement is that the event based study was sensitive to short term market reactions, while the present cross sectional study is sensitive to the average market value over a longer period.

The negative result of the present research contrasts with similar studies reviewed in chapter 2. Most of these studies, which found a positive impact of R&D activity on market value, were carried out in developed economies. This corroborates the prevailing view that South Africa lags developed economies in terms of innovative activity. The result highlights the need for interventions, such as the R&D tax incentive programme, that will stimulate innovative activity and enhance technology transfer between academic institutes and the business sector.

It should be highlighted that the present study takes a broad stroke view of R&D activity in JSE listed companies. The negative result should not detract from individual success stories, where very successful companies have been built out of world class, home grown innovation. It does, however, point to a general concern that local innovation is not contributing to economic growth as much as it should.

Finally, the delimitation of the research to the listed business sector should be emphasised. It may be expected that R&D plays a more significant role in the unlisted sector where small high-tech start-ups reside. The present research does not provide any direct conclusion with respect to this sector.

5.2 Conclusion

The question of the impact of R&D activity on the market value of JSE listed companies has been addressed in this research. Following the literature, a linear model with market value as the dependent variable has been used. This model is derived from the premise that market value is made up of the sum of tangible and intangible assets. Following the primary reference of the research (Johnson and Pazderka, 1993), four explanatory variables are included: book value, abnormal earnings, R&D investment, and net investment. Annual figures for these variables are used, based on the argument that they provide reliable proxies for long term behaviour. Thus current abnormal earnings are taken as a proxy for the long term profitability of a company, and current R&D investment is taken as a proxy for consistent innovative activity. Net investment is included as an indicator of management's confidence in the growth of the business (Johnson and Pazderka, 1993).

The period chosen for the present study was the recent 5-year period, July 2007 to July 2012. This is an interesting period as it includes the 2008/2009 financial crisis. It is found that the model has strong explanatory power, with R^2>90%. Only two of the independent variables, however, play a role in explaining the variance in market value. These are book value, and abnormal earnings. The coefficient of the book value term is found to be indistinguishable from unity, as expected. Current abnormal earnings turn out to be the most important determinant of market value, with a coefficient of approximately 2. Again, this is not a surprising result, since, taken as a proxy of anticipated future cash flow, it is expected that the market places high value on this variable. Similar values for the E^* coefficient were obtained in both the large dataset, which included all observations with positive earnings, and the small dataset which included R&D reporting companies only.

The research variable, R&D expenses, is found to be insignificant at any reasonable level, and so the research fails to reject the null hypothesis. Current R&D expenses do not provide any predictive power regarding the market's valuation of a JSE listed company. Inspection of the data shows that R&D is highly concentrated, and overall companies spend little on R&D relative to turnover. The negative result could indicate that R&D activity in South Africa is simply too small to play a significant role in company valuation. The research therefore fails to reject the null hypothesis that investors do not anticipate future benefits due to R&D activity. It should be noted that this conclusion is limited to the listed business sector in South Africa, and cannot be generalised to unlisted companies. The negative result contrasts with the literature, where studies in the US, Australia, UK, and Canada do observe a significant and positive effect of R&D on market value. This supports the prevailing view that South Africa lags developed economies in growing the economy through innovation.

5.3 Recommendations for Further Research

The results presented here point to further avenues of research which would shed light on the role of R&D, and how R&D investments could be made more effective. Firstly, it should be highlighted that the current study period was highly volatile due to the financial crisis and resulting global recession. The contribution of this to the negative result cannot be discounted. No similar studies in developed economies carried out over the last five years have been identified in the literature. It would therefore be interesting to apply the same methodology to the 5 year period leading up to the crisis. It is possible that a different result would be obtained during a period of certainty and prosperity.

A similar methodology as used in the current research could be used to investigate the effects of other explanatory variables. The impact of advertising spend on the market value of South African companies, would be interesting, for example.

It is clear that South Africa needs an effective innovation strategy in order to reap the benefits of R&D activity. There is a strong technical base in the resource sectors, and this should be leveraged better. Enhancing value adding activities, through beneficiation, could provide a valuable direction for R&D effort. Qualitative research is needed to gain deeper understanding of how to make R&D and technology transfer more effective in South Africa.

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