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Innovative intensity and its impact on the performance of firms in Brazil

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ABSTRACT

This article evaluates whether firms that invest in research and development (R&D) have better future performance and if stock market fully value such intangible investment. The results of annual cross-sectional regressions indicate a strong association between the intensity of R&D and future performance, even after controlling for other variables that affect future performance. However, after controlling for firm characteristics and risk factors, the innovative intensity was not significant in predicting future returns. In general, the results suggest that the R&D intensity is not useful for firm valuation in Brazil.

1. Introduction

The growing importance of intangible assets in a firm's value, and more specifically, the importance of investment in research and development (R&D) in the economy, has generated considerable interest in the subject in recent years, especially in developed countries, regarding the way the capital market establishes prices and/or reacts to investments in R&D.

However, it is not a simple task to accurately reflect the intangible benefits of investing in R&D in the value of assets, mainly because the accounting information does not adequately reflect such intangible assets.

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Moreover, even if it was expected that the price of an asset incorporated all the available information, including any information relating to intangible assets as well as the benefit of investment in R&D, several studies show that the market does not fully and immediately incorporate even publicly available information. This contradicts the hypothesis of market efficiency (DellaVigna and Pollet, 2009; Hirshleifer et al., 2009; Hou et al., 2009).

Thus, it is expected that the ability to incorporate intangible information into asset prices would be even more valuable. In reality, investors have more difficulty assessing information when it is intangible (Daniel and Titman, 2006) or difficult to process (Song and Schwarz, 2010) as is the case of investment in R&D, where results are highly unpredictable and often associated with untested technologies or processes.

Moreover, the long-term nature of investment in R&D may be incompatible with the time frame with which investors are concerned, as suggested by Hall and Hall (1993) who conclude that investors fail to identify rewards arising from long-term investments.

The issues mentioned concerning the difficulty of accounting for investment in innovation (which assume even greater importance in a modern economy, where much of a firm's value may be a function of its intangible assets), together with the magnitude of recent public policies to encourage innovation[1] in Brazil, demand an analysis of the impact of such investments on business performance and how the market in Brazil reacts to this information.

The inexistence of studies of this nature in Brazil shows the importance of the contribution of our study, with the aim of helping companies and authorities formulate R&D policies in Brazil. In additions, it sheds light on the issue for emerging economies.

This article evaluates the relationship between the intensity of R&D expenditures and (1) operational performance and (2) returns on equity. Given that R&D expenditures bring long term benefits, we analyze the impact in up to 3 years after the expenditures. We opted for 3 years instead of 5, as commonly seen in the literature, because of limitations on the quality and quantity of data, required for such a study, in Brazil. To consider 5-year effects of R&D would lead to considerable loss of data observations.

We treat R&D efforts as innovation intensity, for which we use as proxy Investment in R&D divided by sales (R&D/sales) or divided by equity market value (R&D/MV), as proposed by Chan et al. (2001).

If indeed investors do not incorporate quickly and adequately investments in R&D, be it because of difficulties in the evaluation of its implications, be it because of difficulties in identifying such investments from financial reports, then we would expect firms which invest more in innovation to be undervalued when compared to firms with little investments in D&D.

Therefore, if the investment in innovation is in fact underestimated, as appears to be the case in the studies developed in the US and England, the investment in company innovation could be inhibited, given the benefits granted by investors to less innovative companies

This study evaluate the market's ability to incorporate the intangible benefits of investing in R&D.

We perform cross-sectional Fama–MacBeth regressions, as described in Hirshleifer et al. (2013) and find a positive and significant relationship between innovation intensity and performance, where performance is measured by Return on Assets (ROA). However, even with better future performance, companies with more intensity in innovation do not appear to show better returns than those with less investment in innovation. These results were found with the use of buy-and-hold portfolio techniques, as commonly seen in the literature. These results were confirmed by cross-sectional Fama–MacBeth annual regressions between returns and innovation intensity, controlling for other characteristics of the firms.

Additionally, for every year we form 3 portfolios based on innovation intensity at the beginning of July and carry them for 12 months. After regressing the excess returns of these portfolios against the returns for the Fama–Fench 3-factor model, we again did not find abnormal alfas.

[1] In 2013, Brazil launched the largest integrated plan in its history to promote investment in innovation in order to raise the competitiveness of the Brazilian economy. The Innovate Company Plan foresees the involvement of different ministries, through which more than US$ 30 billion will be invested in innovation by 2014 (http://www.finep.gov.br/inovaempresa/). The goal of the plan reveals the expectation of improvement associated with the expansion of investment in innovation.

The remaining of this article is organized as follows. Section 2 performs a review of the literature about the relationship between R&D and future performance and return on equity Section 3 presents the data, the specification of the measures of innovation intensity and a statistical summary. Section 4 shows the results, while Section 5 present the main conclusions of the study.

2. Literature review

The first studies on the relationship between investment in R&D and future financial performance emerged in association with the evaluation of the impact of other intangible types of investments, i.e., marketing expenditures. This association arises due to the need, identified in these studies, to capitalize on investments made in these items and depreciate them over time, since they create value for several years after expenditure.

Ben-Zion (1978), Griliches (1981), Hirschey (1982), Bublitz and Ettredge (1989), and Chauvin and Hirschey (1993), evaluated the effect of intangible investment in marketing and R&D on the market value of equity of a firm. The authors found a positive relationship between the intensity of R&D and a firm's market value. Marketing expenditures were also significant in explaining market value.

Sougiannis (1994) evaluated the relationship between investment in R&D and firm value and found evidence indicating that a one-dollar investment in R&D promotes an increase of five dollars in the firm's market value. The author attributes this effect on market value to two causes, one direct and one indirect. The direct effect refers to new information regarding research and development itself, while the indirect effect refers to the value of investing in R&D that is expected to persist in the result. On average, the latter is larger than the former.

However, when assessing whether the capital market incorporates the benefits of investment in intangible assets, using an investment strategy based on the intensity of R&D, Chan et al. (2001) found no evidence of association between future returns and the intensity of R&D when the latter was measured by outside investment in R&D over sales. Meanwhile, this association was stronger when the intensity measure used was R&D over the market value of equity. In this case, the quintile of more intensive R&D companies had an average return in excess of 6.12% over the control portfolio (consisting of companies that do not invest in R&D) in the three years following the formation of the portfolio.

Eberhart et al. (2004) analyzed the reaction of the market, not to the intensity of investment in innovation, but rather to the significant and unexpected increase in R&D investment by North American companies between 1951 and 2001. The authors reported that the market reacts slowly, based on the observance of positive and significant long-term abnormal returns after such increases. As investors experience significant abnormal returns in the five years after an unexpected increase in R&D, the authors also found that companies experience significant positive abnormal operating performance in the five years after observing an increase in R&D.

Upon comparing the performance of leading versus following companies, the former being those that have a higher intensity of R&D in relation to the industry, Lev et al. (2006) found that leading companies maintained a better performance for at least four years thereafter; although they had worse profitability in the initial higher investment year. However, similar to Eberhart et al. (2004), the authors also concluded that the market reacts slowly to information around the benefits of investing in R&D, which can be observed through the higher risk-adjusted excess returns among the leading companies.

Pandit et al. (2011) evaluated the relationship between inputs and outputs of innovation and future operating performance. Using expenditure on R&D as a proxy for the inputs of innovation and patent citations for the outputs, the authors also found a positive relationship between the quantity and quality of patents and future operating performance.

Hirshleifer et al. (2013) showed that a firm's innovative efficiency, measured by the number of patents, or patent citations, divided by investment in R&D, was strongly and positively associated with the presence of future excess returns.

Just as in the international literature, in Brazil the research on the relationship between investment in innovation and the value or performance of companies is not conclusive.

Hungarato and Sanches (2006) conducted a study of events and identified a positive and significant variation in the abnormal returns of high-tech companies, after analyzing price changes between 30 and 60 days after the disclosure of spending on R&D.

Alves et al. (2010), in turn, evaluated the relationship between spending on R&D and stock prices in Brazil for electricity distribution companies, since firms in this sector are required to apply a percentage of their Net Sales in R&D. However, after controlling the impact of investment in R&D by earnings and net worth, the variable was not significant. Hungarato and Teixeira (2012) evaluated the relationship between spending on R&D and stock prices in Brazil and did not find a significant positive relationship between these.

In a recent study, Fernandes et al. (2013) evaluated the impact of the number of generated patents and investment in R&D on the value of firms in Brazil between 2007 and 2009. Patent information was not significant and investment in R&D was significant, but negative, suggesting that the market interprets the R&D expenditures as expenses only, and not as investments that generate long-term benefits.

It is noteworthy, however, that no study in Brazil conducted a set of tests and worked with a sample and period as broad as those used in this research to evaluate the impact of investment in R&D on asset prices.

3. Methodology—Sample composition and statistical summary

To evaluate the relationship between innovative intensity and the performance of stocks in Brazil, portfolios were formed using data from July of year t and June of year $t+1$, following the methodology proposed by Fama and French (1992). The sample consists of all stocks listed on the São Paulo Stock Exchange (BM&FBOVESPA) between July 31, 2005 and June 31, 2013, excluding financial firms and those that did not have the following attributes: (i) Consecutive monthly quotes for a period of 12 months after the portfolios were formed; (ii) Equity market value on December 31st and June 30th prior to the portfolio formation period; with five-day tolerance and; (iii) positive book value of equity on December 31st prior to the portfolio formation period; with a tolerance of five days.

This sample used the information about investment in R&D found in the annual financial statements available from the Securities and Exchange Commission of Brazil (CVM da sigla em português) website between 2004 and 2012. The portfolios were formed with a three-month delay from the publication of data on investment in R&D; in Brazil, companies have until March 31st of the following year to publish their financial statements. Thus, the classification of the innovative intensity of the shares comprising a portfolio formed in July 2005, for example, takes into account the investment in R&D in 2004, the notification of which may be made until March 31st, 2005. This delay is to ensure that all investors have access to information and sufficient time to incorporate it into their pricing processes.

Observing these criteria, we obtained an average of 140 firms for the periodanalyzed, of which, on average, 37 reported an investment in R&D. Table 1 shows the number of companies per period.

It is worth noting that the year 2004 was marked by the revival of the capital market in Brazil and the consequent resumption of share offerings. Thus, the option to start the analysis in 2005 is due to increased trading volume and the liquidity of the securities market after this period, which significantly improved the quality and quantity of available data. Moreover, the quality of information on research and development also began to improve significantly as of 2005, due to an increased need for transparency resulting from the high standards of corporate governance required by a more active capital market.

It can be observed in Table 1 that despite the greater importance given to the topic of innovation, the percentage of companies that reported investment in R&D over the analysis period remained essentially unchanged, resulting in, on average, 26%. The highest percentage was found in the portfolio with data from July 2007 to June 2008, a period that coincides with the boom of initial public offerings (IPOs) in Brazil; in this instance, 68 companies were drawn to the capital markets; 64 in 2007 and only 4 in 2008, reflecting the effects of the global financial crisis. This may be an indication that the greater liquidity of the capital market and the consequently greater resources available encouraged companies to take greater risks and broadened the participation of investment in R&D in company growth plans.

Table 1
Number of shares of the sample by period.

Period	Jul05–Jun06	Jul06–Jun07	Jul07–Jun08	Jul08–Jun09	Jul09–Jun10	Jul10–Jun11	Jul11–Jun12	Jul12–Jun13	Average
Number of shares	68	88	118	130	168	177	184	184	140
Number of shares with R&D expenditure	17	23	35	36	41	47	47	46	37
%	25%	26%	30%	28%	24%	27%	26%	25%	26%

Table 2
Statistical summary@@@.

	R&D/market value			R&D/sales			Without R&D
	Low	Medium	High	Low	Medium	High	
Panel A: characteristics							
Size (US$ million)	8292.69	9645.53	1667.56	6706.59	7367.20	3729.62	1656.65
Investments in R&D (US$ million)	9.55	59.45	44.17	7.97	44.92	56.53	0.00
R&D/market capitalization (%)	0.14	0.67	2.46	0.20	0.76	2.68	0.00
R&D Capital	38.85	125.27	119.58	33.09	83.27	151.69	0.00
Book To Market Equity	0.57	0.49	0.68	0.70	0.81	0.48	0.60
Capex/assets (%)	3.89	6.08	4.51	4.32	4.49	4.45	4.70
Capex/market capitalization (%)	4.66	7.52	7.68	6.30	8.95	3.83	6.60
Momentum (%)	12.06	8.61	6.19	14.00	7.38	8.44	8.49
Marketing/market capitalization (%)	0.29	0.14	0.38	0.33	0.17	0.29	0.46
Average number of firms	12	11	13	12	11	13	103
Firm–year Observations	1188	1116	1200	1188	1116	1200	9900
Panel B: performance							
Return on assets							
Portfolio formation year	9.53	9.90	5.59	7.51	6.12	8.81	4.94
One year after portfolio formation	8.40	7.81	4.91	6.41	5.20	7.84	3.97
Average of three years after portfolio formation	9.02	8.70	4.91	7.46	5.26	7.73	4.24
Overall three years after portfolio formation	29.89	28.65	15.43	24.32	16.70	25.26	13.18
EBITDA margin							
Portfolio formation year	32.89	24.66	15.66	27.70	27.38	18.16	16.28
One year after portfolio formation	29.48	23.20	16.05	24.57	24.84	17.35	13.86
Average of three years after the portfolio formation	29.01	23.77	15.44	25.62	25.71	17.54	14.87
Overall 3 years after the portfolio formation	116.16	89.88	54.11	100.14	98.96	62.73	51.10
Operating margin							
Portfolio formation year	27.11	19.16	11.48	21.56	20.56	14.27	11.46
One year after portfolio formation	21.91	17.69	11.24	17.87	18.06	12.72	9.55
Average of three years after the portfolio formation	23.18	17.49	11.63	19.83	18.44	13.47	9.86
Overall 3 years after the portfolio formation	88.05	62.10	39.41	73.47	66.27	46.30	31.91

Except for data on R&D, all other financial information was collected from the Bloomberg database; namely, the share price for the calculation of returns (RET) and momentum (MOM) (estimated by the cumulative return six months before the formation of the portfolio with a gap of one month), market value of equity (MV), book value of equity, book-to-market equity (BTM), total assets (TA), net revenue (NR), earnings before interest, tax, and depreciation (EBITDA), operating profit measured by earnings before interest, tax, and social contribution on net income (EBIT), return on assets (ROA), capital expenditures (CAPEX), and marketing expenditures (MKT).

Table 2 reports the statistical summary for different portfolios formed based on the intensity of investment in R&D. In June of each year, three portfolios were formed based on the 33rd and 66th percentiles of innovative intensity, measured by investment in R&D in the year prior to the re-evaluation of the market value for the same period ($R\&D_{t-1}/MV_{t-1}$). The same procedure was adopted by dividing the investment in R&D by the annual net revenue ($R\&D_{t-1}/Sales_{t-1}$). Additionally, Table 2 shows the statistical summary for the companies that did not report R&D investments during the period covered by the study.

Even though the effort to innovate in an organization can be associated with activities not related to R&D, such as the purchase of goods or external knowledge, it is worth noting that this study covers only

the impact of investment in R&D. Therefore, whenever investment in innovation or innovative activities are mentioned, it should be noted that the impact of R&D activities is being assessed exclusively.

The summary presents the median values of the selected features in panel A, except for number of firms and firm-year observation, which present the mean and the total, respectively. All characteristics are related to December of the year prior to portfolio formation, except the size and momentum variables. These refer to the month of June immediately preceding the formation of the portfolios. We opted for the presentation of median values to minimize the effect of outlier values, given that the distribution of the firms' characteristics was highly asymmetric.

However, Panel B shows the performance measures for each portfolio (low, medium, and high intensity of R&D investment) for the year of portfolio formation (t); for the subsequent year ($t+1$), and the average performance observed in three years (t, $t+1$, and $t+2$) as well as the accumulative performance over this period.

For portfolios formed on the basis of R&D/MV, the median market value was R$ 1.67 billion, 9.65 billion, and 8.29 billion for the high, medium, and low innovative intensity portfolios, respectively. In that order, for R&D/sales portfolios, the market values were R$ 3.7.70 billion, 7.4 billion, and 6.7 billion. As expected, the smaller companies were those that invested most in R&D in relation to their market value or annual net revenue. However, the median market value of firms that did not invest in R&D was R$ 1.66 billion, lower than the median value of all portfolios formed. Apparently, in the Brazilian capital market, investment in innovation is concentrated in larger companies.

There are certain reasons that justify such an idiosyncrasy in the capital markets in Brazil. The first is the high average level of market capitalization of companies accessing the capital markets, given the difficulty that minor companies face in accessing this funding source. To give a basis for comparison, Hirshleifer et al. (2013) reported median market values of US$ 215.45 million, 626.79 million, and 42.55 million for portfolios of high, medium, and low innovative efficiency, respectively, formed between 1982 and 2007, using an average of 424 companies per portfolio, all traded on one of the following U.S. stock exchanges: NYSE, AMEX or NASDAQ.

This difficulty of access to capital markets in Brazil, (which is not the subject of this research), can be seen in the number of *shares* listed on the "Bovespa Mais", listing segment created by São Paulo Stock Exchange (BM&FBOVESPA) to improve access for small and medium-sized companies to capital markets. Launched in 2005, the segment has only nine companies listed.

Another problem lies in the quality of disclosure regarding investment in innovation. Since such information is proprietary, details about innovation projects are often omitted from company reports. Even information regarding the volume of R&D expenditures is difficult to access. Thus, it is possible for smaller companies to devote less importance to the publication of this information, since they are less susceptible to pressure from investors requiring greater transparency.

Finally, it is possible that the filters adopted in this research eliminated smaller companies that would potentially have innovation as part of their growth strategy; namely, the filtering of firms that had no market value in December and June prior to the portfolio formation period and those that did not have returns for 12 consecutive months after portfolio construction.

The companies that innovate most intensively invest 2.46% and 2.68% of their market value in R&D for portfolios based on investment in R&D/MV and R&D/sales, respectively. While low investment portfolios allocated the equivalent of 0.14% and 0.20% respectively. Chan et al. (2001) conducted a similar analysis by organizing the sample into quintiles for the period 1975 to 1995; according to the authors, investment in R&D divided by market value on the quintile of more intensive R&D companies was 16.55% for R&D/MV portfolios and 10.88% for R&D/Sales portfolios. Meanwhile, for the less intensive company quintile, the percentages were 0.68% and 1.3%, respectively.

Moreover, Panel A presents the book to market values, calculated as book value of equity divided by the market value of the shares in year $t-1$. Capex and marketing expenses divided by market value are also at $t-1$. Additionally, the momentum is the prior six months returns with a one-month gap between the holding period and the current month, i.e., for portfolios formed in July, the return refers to the period from January to June of year t.

Panel B presents three measures of operating performance for each of the portfolios, namely return on assets (net income over total assets), the EBITDA margin (EBITDA/net sales) and operating margin (EBIT/net income). All portfolios that invest in R&D have a superior performance, measured by ROA,

to companies that do not invest. When comparing the portfolios of different intensities, those of high R&D/sales show ROA slightly higher than those with low R&D/sales. The cumulative ROA of this portfolio in three years is 25.26% versus 24.32% for companies with low intensity. However, this pattern is not confirmed by portfolios formed on the basis of R&D/market value.

Regarding operating margins, virtually all portfolios with investment in R&D also have better performance than the portfolio of companies that did not invest in innovation; mainly, portfolios of low and medium intensity. The worst performance of the most intensive firms, when measured by margin, can be explained by the need for such companies to account for R&D expenditures directly in their results. This contributes to a worse annual performance even if investment in R&D yields benefits in future activities.

This effect is minimized when evaluating performance by ROA, since the metric result (net income in the above case) is affected by spending on R&D, but not the asset measurement. Thus, the measurement of performance by ROA reflects the effect of spending on R&D in the result, but minimizes the impact by dividing a company's net income by its assets; ROA tends to be lower for companies that are more R&D intensive and therefore have a greater volume of intangible investments.

For this reason, in the next section we will further evaluate the relationship between the intensity of investment in R&D and future operating performance, measured by ROA.

4. Analysis of results

4.1. Relationship between innovative intensity and operational performance

To assess the relationship between innovative intensity and future operating performance, we used cross-sectional annual regressions according to the methodology proposed by Fama and MacBeth, 1973.

According to Goyal (2012), the methodology of Fama–MacBeth, pioneer in the use of a two-stage procedure, is largely utilized in the international literature for asset pricing.

While in the first stage betas are obtained with regressions using historical data, the second stage uses cross-sectional regressions of the actual returns against the betas estimated in the first stage.

One of the major advantaged of the Fama–MacBeth method is that it allows easy handling of non-balanced panels, as it was necessary in our study, given that the number of companies changes at each period. This is possible because, according to Goyal (2012), the distribution of risk premia does not depend on the number of firms.

Another advantage of Fama–MacBeth is that it is not necessary to calculate variances of the coefficients at each period, which would demand considerations about transversal correlations, but it computes the variance of the mean coefficients, which are calculated with the use of historical coefficients.

In addition, to avoid the possibility that autocorrelation of returns, less likely with monthly data, would lead to autocorrelation of the estimated risk premia, we estimated the *t*-statistic using the methodology of Newey and Kenneth (1987) for corrections of heterocedasticity and serial autocorrelation.

Thus, for each portfolio formed in July of year *t*, Fama–MacBeth cross sectional annual regressions were run, according to the following equation:

$$\begin{aligned} \mathrm{ROA}_{i,t+1} = {} & \alpha_0 + \alpha_1 \ \ln\left(1 + \mathrm{IN}_{i,t}\right) + \alpha_2 \ln\left(1 + \frac{\mathrm{MKT}_{i,t}}{\mathrm{MV}_{i,t}}\right) \\ & + \alpha_3 \ln\left(1 + \frac{\mathrm{Capex}_{i,t}}{\mathrm{MV}_{i,t}}\right) + \alpha_4 \, \mathrm{ROA}_{i,t} + \alpha_5 \ \Delta\mathrm{ROA} \end{aligned} \tag{1}$$

where $\mathrm{ROA}_{i,t+1}$ is the operating performance measured on returns in year $t+1$; $\ln(1+\mathrm{IN}_{i,t})$ is the natural logarithm of one plus the innovative intensity, measured by investment in R&D/MV or R&D/sales; $\ln(1+\mathrm{MKT}_{i,t}/\mathrm{MV}_{i,t})$ is the natural logarithm of one plus marketing expenses divided by market value of equity; $\ln(1+\mathrm{Capex}_{i,t}/\mathrm{MV}_{i,t})$ is the natural logarithm of one plus capital investments over market

Table 3
Innovative intensity and future operating performance.

	Panel A: R&D/MV	Panel B: R&D/sales
Intercept	2.71 (1.91)*	2.56 (1.87)*
ln(1 + innovative intensity)	0.70 (2.48)**	1.21 (2.32)**
ln(1 + MKT/MV)	−0.24 (−0.87)	−0.18 (−0.64)
ln(1 + Capex/MV)	−0.65 (−3.78)***	−0.60 (−3.59)***
Current ROA	0.70 (6.04)***	0.69 (5.80)***
ΔROA	0.00 (0.36)	0.00 (0.32)

***, ** And * indicate significance at the level of 1%, 5%, and 10%, respectively.

value of equity; $ROA_{i,t}$ is the operational performance of year t; and $\Delta ROA_{i,t}$ is the variation of return on an asset between year t and year $t+1$.

For the variables Innovative Intensity, Capex/MV, and MKT/MV, we used the natural logarithm of 1 plus the variable since there is high asymmetry in the distribution of these variables, and some of them can have a zero value in some cases.

In assessing the relationship between intensity and innovative future performance, we control the results by Capex and marketing expenses, given that Pandit et al. (2011) and Hirshleifer et al. (2013) found a significant association between these variables and future performance.

We also included the current operating performance ($ROA_{i,t}$) and the variation of operating performance ($\Delta ROA_{i,t}$) in the equation to capture the continuing operational performance and profitability reversion, respectively.

Table 3 shows the average coefficients obtained from the annual cross-sectional regressions as well as their corresponding t-statistics in parentheses. Panel A shows the coefficients using R&D/MV as a measure of innovative intensity, while Panel B uses R&D/sales.

For the two measures of innovative intensity, we observed a positive and significant relationship with performance in the following year. An increase of one standard deviation in ln(1 + R&D/MV) generates an increase of 0.7% in future profitability and the same increase in ln(1 + R&D/Sales) causes an increase of 1.21%, both significant at the 5% level.

Unlike the results in the international literature, the ln(1 + MKT/MV) and ln(1 + Capex/MV) variables presented negative signs. Marketing expenses were not significant in explaining returns in the subsequent period, but the Capex proved significant at 1%. This result may indicate that Capex investments increase assets in the following year, but this increase is not accompanied by profit growth; at least not in the same year.

The current profitability was also highly significant in explaining future profitability, confirming the persistence of returns on future performance. However, the hypothesis of average reversion in profitability is not confirmed for the Brazilian capital market considering the period.

Thus, in the future performance of firms there is an increased importance of investment in intangible assets, whether innovation intensity is measured by investment in R&D/MV or R&D/sales.

4.2. Innovative intensity and expected returns

4.2.1. Forming portfolios based on R&D/market value

To evaluate the relationship between investment in R&D and future returns, portfolios were formed and categorized based on the innovative intensity in July of each year and we assessed the returns of this portfolio during three years, beginning from year of formation.

The portfolios formed in July of year t were rebalanced based on the 33rd and 66th percentiles of R&D/MV of December of year $t-1$. This six-month delay is intended to ensure that information on R&D expenditures is available to all investors, since the deadline for submission of financial statements in Brazil ends on March 31st of the following year.

Table 4 shows the returns for the three years following July of year t for each of the three portfolios formed on the basis of R&D/MV. Panel A shows the results for equally weighted portfolios returns, while Panel B presents the results for the value–weighted portfolio at market value of equity in June of year t.

Table 4
Returns of portfolios classified by R&D expenditure/equity market value (Jul/2005–Jun/2013).

Panel A: Equally weighted Portfolios						
Innovative intensity = R&D/market value						
	Without R&D	Low	Medium	High	High–low	*t*-Stats
Panel A.1: annual return within three years of the formation of the portfolio						
Year 1	0.0988	0.1050	0.0655	0.0589	−0.0461	−0.6184
Year 2	0.0515	0.0493	0.0048	0.0361	−0.0132	−0.1995
Year 3	−0.0202	0.0126	−0.0640	−0.0139	−0.0264	−0.2956
Panel A.2: excess return on the portfolio formed based on size						
Year 1	–	0.0636	0.0369	−0.0176	−0.0812	−1.1060
Year 2	–	0.0235	−0.0111	−0.0128	−0.0363	−0.6090
Year 3	–	0.0418	−0.0522	−0.0063	−0.0481	−0.4603
Panel A.3: excess return on the portfolio formed based on size and BTM value						
Year 1	–	−0.0090	0.0266	−0.0020	0.0070	0.1931
Year 2	–	−0.0543	0.0094	−0.0084	0.0458	0.5881
Year 3	–	−0.0459	−0.0110	−0.0255	0.0204	0.2437
Panel B: value–weighted portfolios						
Innovative Intensity = R&D/market value						
	Without R&D	Low	Medium	High	High–low	*t*-Stats
Panel B.1: annual return within three years of the formation of the portfolio						
Year 1	0.0748	0.0871	0.0369	0.0265	−0.0606	−0.5734
Year 2	6.3538	−0.0004	−0.0345	0.0521	0.0525	0.8634
Year 3	1.9703	−0.0634	−0.0663	−0.0523	0.0111	0.0565
Panel B.2: excess return on the portfolio formed based on size						
Year 1	–	0.0719	−0.0165	−0.0052	−0.0771	−0.7387
Year 2	–	0.0034	−0.0760	0.0181	0.0147	0.2408
Year 3	–	−0.0432	−0.0945	−0.0678	−0.0246	−0.1215
Panel B.3: excess return on the portfolio formed based on size and BTM value						
Year 1	–	0.0173	−0.0181	0.0575	0.0403	0.4013
Year 2	–	−0.0163	0.0108	0.0428	0.0590	0.5514
Year 3	–	−0.0645	−0.0843	0.0074	0.0719	0.6152

***, ** And * indicate significance at the level of 1%, 5%, and 10%, respectively.

Although it is expected that more R&D intensive companies are associated with higher future returns, the difference between the returns of companies with high and low innovative intensity was not statistically significant for the three years following the formation of the equally and value-weighted portfolios (Panel A.1 and B.1).

Aiming to control for the effects caused by specific company characteristics in the returns, given that stocks with high innovative intensity measured by R&D/MV values are smaller and have higher BTM values, in July of each year *t*, control portfolios were formed based on these characteristics, composed of companies that did not invest in R&D. Panels A.2 and B.2 show the excess returns of each of the portfolios classified according to innovative intensity in relation to the control portfolio, formed based on market value. All companies in the control portfolio have a minimum and maximum size equivalent to each of the portfolios formed based on innovative intensity. Panels A.3 and B.3 present the returns in excess of the control portfolio formed in relation to company size and BTM value together.

Even after controlling for size, the returns of firms with higher R&D/MV were lower in the three years evaluated for equally weighted portfolios and in the first and third year for value-weighted portfolios (panels A.2 and B. 2, respectively). However, when controlled for size and BTM value, the excess returns of the most innovative companies with less intensity exceeded intensive companies every year; this occurred for both the equally weighted portfolios as well as for those value-weighted,

Table 5
Returns of portfolios classified by R&D expenditure/Equity Market Value (Jul/2006 – Jun/2013).

Panel A: Equally weighted Portfolios						
Innovative Intensity (R&D/market value)						
	Without R&D	Low	Medium	High	High–Low	*t*-Stats
Panel A.1: annual return within three years of the formation of the portfolio						
Year 1	−0.0189	−0.0204	−0.0291	−0.0379	−0.0175	−0.2061
Year 2	−0.0316	0.0088	−0.0569	−0.0241	−0.0329	−0.4388
Year 3	−0.0142	−0.0120	−0.0903	0.0353	0.0474	0.7674
Panel A.2: excess return on the portfolio formed based on size						
Year 1	–	0.0233	0.0107	−0.0003	−0.0236	−0.3162
Year 2	–	0.0604	−0.0219	0.0058	−0.0546	−0.8137
Year 3	–	−0.0018	−0.0811	0.0378	0.0396	0.5686
Panel A.3: excess return on the portfolio formed based on size and BTM value						
Year 1	–	0.0037	−0.0031	0.0022	−0.0016	−0.0348
Year 2	–	−0.0128	−0.0017	−0.0157	−0.0030	−0.0411
Year 3	–	−0.0953	0.0338	−0.0219	0.0734	0.9236
Panel B: Value–weighted Portfolios						
Innovative Intensity = R&D/market value)						
	Without R&D	Low	Medium	High	High–low	*t*-Stats
Panel B.1: annual return within three years of the formation of the portfolio						
Year 1	0.0576	0.0199	−0.0200	−0.0092	−0.0292	−0.2505
Year 2	0.0118	−0.0527	−0.0904	0.0220	0.0747	1.1161
Year 3	0.0291	−0.1233	−0.1574	0.0764	0.1997	2.8062***
Panel B.2: excess return on the portfolio formed based on size						
Year 1	–	0.0182	−0.0657	−0.0183	−0.0366	−0.3294
Year 2	–	−0.0180	−0.0985	0.0236	0.0416	0.6393
Year 3	–	−0.1129	−0.1947	0.0562	0.1691	2.3720**
Panel B.3: excess return on the portfolio formed based on size and BTM value						
Year 1	–	−0.0333	−0.0449	0.0550	0.0883	0.8676
Year 2	–	−0.0586	0.0143	0.0183	0.0769	0.6155
Year 3	–	−0.1576	0.0345	0.0234	0.1810	3.5263***

***, ** And * indicate significance at the level of 1%, 5% and 10%, respectively.

and this difference increased over time. The differences were greater in the value-weighted portfolios, with 4.03% in the first year and 7.19% in the third. However, again, the differences were not statistically significant. It is noteworthy that, despite the significant magnitudes in some cases, the differences between the returns of high and low intensity stocks were not significant and, perhaps, the short time series (8 years) contributed to this, since the smaller the number of observations, the harder it is to identify statistical relationships.

Furthermore, it should be noted that the results above are significantly affected by the high concentration of the portfolios formed in 2005. Because of the small number of companies that reported investment in this period, due to the poorer quality of the dissemination of information on R&D expenditures and less importance given to this issue at the time, Embraer, for example, accounted for 84.86% of the market value of the portfolio of high innovative intensity companies. Still, Petrobras and Vale accounted for 87% of the portfolio of medium intensity companies. The focus on the low intensity portfolio was minor, with the largest share in 2005 represented by Usiminas, with 36.85% of the market value of the portfolio.

In later years, this concentration decreased with the increasing number of companies in the portfolio. Beginning in 2006, Embraer, for example, did not represent more than 25% of any portfolio.

Thus, Table 5 shows the returns of the buy and hold portfolios, excluding the portfolio formed in July 2005.

For this period, the difference between the returns of low and high intensity portfolios becomes positive for the equally weighted portfolios, with the largest magnitude presented after controlling performance for size and BTM value. In this case, the portfolios with higher R&D/MV outperformed low intensity portfolios at 7.34% (Panel A.3—Table 5); although, this difference was not statistically significant.

For value weighted portfolios, once again all analyses indicate that the long-term portfolios formed by more innovative firms performed better in the long run, and such differences were considered significant.

Panel B.1 shows that the difference between the returns of companies that invest intensely in R&D and companies that invest less is 19.97% in the third year; significant at 1%. When controlled for size together with BTM value, the differences are 16.91% and 18.1%, respectively; the first being significant at 5% and the second at 1%.

Although the same analyses were performed by forming portfolios based on investment in R&D/sales, the results obtained in non-reported analyses do not alter the conclusions reached when using R&D/MV as formation criteria.

Thus, considering the analyses performed between July 2006 and June 2013, the results indicate that companies that are more R&D intensive are associated with higher long-term returns. These results are compatible with the characteristics of innovation projects whose benefits are normally expected over extended periods of time.

4.2.2. Monthly cross-sectional regressions

With the goal of providing more robustness to the analysis of the relationship between investment in R&D and stock returns, the following regressions were performed: cross sectional monthly regressions of excess returns for each stock between July of year t and June of year $t+1$, against the natural logarithm of one plus the innovative intensity and other control variables. Thus, between July 2005 and June 2013, 96 regressions were generated for each model, totaling 480 regressions. As in Fama and MacBeth, 1973, in order to infer the significance of the explanatory variables, the temporal variation of the coefficients obtained in the monthly cross-sectional regressions was used.

We initially evaluated the relationship between excess returns and control variables in order to verify the explanatory power of these variables without the inclusion of the intensity of investment in R&D:

$$R_{i,t} - \mathrm{rf}_{i,t} = \alpha_0 + \alpha_1 \ln\left(\mathrm{MV}_{i,t}\right) + \alpha_2 \ln\left(\mathrm{BTM}_{i,t-1}\right) + \alpha_3 \mathrm{Mom}_{i,t} + \varepsilon_{i,t} \quad (2)$$

where $R_{i,t}$ is the monthly return of stock i; $\mathrm{rf}_{i,t}$ is the monthly interbank deposit certificates (CDI), used as a proxy for risk free rate; $\ln(\mathrm{MV}_{i,t})$ is the natural logarithm of the equity market value in June of year t; $\ln(\mathrm{BTM}_{i,t-1})$ is the natural logarithm of the book-to-market index in December of year $t-1$; $\mathrm{Mom}_{i,t}$ is the cumulative return over the six months prior to the current month, with a gap of one month between six months and the current month; and $\varepsilon_{i,t}$ is the residue of regression.

We subsequently evaluated the relationship between excess returns and the level of expenditure on R&D to then run a complete model, including control variables, according to following equations:

$$R_{i,t} - \mathrm{rf}_{i,t} = \alpha_0 + \alpha_1 \ln\left(1 + \mathrm{IN}_{i,t-1}\right) + \varepsilon_{i,t} \quad (3)$$

$$R_{i,t} - \mathrm{rf}_{i,t} = \alpha_0 + \alpha_1 \ln\left(1 + \mathrm{IN}_{i,t-1}\right) + \alpha_2 \ln\left(\mathrm{BTM}_{i,t-1}\right) + \alpha_3 \ln\left(\mathrm{BTM}_{i,t-1}\right) + \alpha_4 \mathrm{Mom}_{i,t} + \varepsilon_{i,t} \quad (4)$$

where $\ln(1+\mathrm{In}_{i,t-1})$ is the natural logarithm of one plus the metric of innovative intensity, measured by the ratio R&D/MV or R&D/sales (Table 6).

The results of the base model, defined by Eq. (2), indicate that the three control variables used are significant in explaining returns. During the assessed period, companies with higher book-to-market equity and momentum and of smaller size are associated with higher returns.

Innovative intensity presented a negative sign, but it was not significant in explaining stock returns either when measured by R&D/MV or R&D/sales. As in Nguyen et al. (2010), the association

Table 6
Cross-sectional regressions of monthly returns against the R&D intensity and other variables.

	Eq. (2)	Panel A = R&D/MV		Panel B = R&D/sales	
		Eq. (3)	Eq. (4)	Eq. (3)	Eq. (4)
Interception	4.945 (1.632)	−0.101 (−0.162)	5.176 (1.706)*	−0.096 (−0.155)	5.027 (1.659)*
ln(1 + Innovative intensity)		−7.708 (−0.865)	−6.969 (−0.780)	−12.646 (−1.493)	2.979 (0.373)
ln(market equity)	−0.229 (−1.744)*		−0.238 (−1.817)*		−0.233 (−1.776)*
ln(BTM)	0.302 (1.861)*		0.305 (1.864)*		0.307 (1.876)*
Momentum	0.016 (1.985)**		0.016 (2.011)**		0.016 (2.016)**

***, ** And * indicate significance at 1%, 5%, and 10%, respectively.

of investment in R&D/sales with diminishing returns seems to come from other characteristics, since the inclusion of control variables in Eq. (4) made the sign of innovative intensity positive.

However, investment in R&D showed no significant effects on stock returns, suggesting that investors price these companies adequately or do not differentiate between more and less innovative companies in Brazil.

4.2.3. Risk-adjusted returns of portfolios formed from levels of innovative intensity

In addition to the cross-sectional regressions, we evaluated the performance of portfolios classified by innovative intensity, controlling the differences in risk factors by means of the three factors of the Fama and French (1993) model. In order to do this we carried out temporal regressions according to the following equation:

$$R_{i,t} - \mathrm{rf}_t = \alpha_{i,t} + \beta_{i,t}^{\mathrm{MKT}}\mathrm{MKT}_t + \beta_t^{\mathrm{SMB}}\mathrm{SMB}_t + \beta_{i,t}^{\mathrm{HML}}\mathrm{HML}_t + \varepsilon_{i,t} \quad (5)$$

where $R_{i,t} - \mathrm{rf}_t$ is the monthly return of each share in excess of the risk free rate, measured by CDI; MKT is the premium of the market portfolio in Brazil, obtained from the difference between the monthly returns of the Ibovespa, used as a proxy for the market portfolio, and the risk free rate.

The SMB and HML factors account for the returns of smaller stocks minus the returns of the biggest shares and the difference between the returns on stocks with high book-to-market ratios and low book-to-market ratios, respectively. To estimate these factors, the methodology proposed by Fama and French (1993) was adopted.

Table 7 presents the regression results of the three-factor model for portfolios classified according to innovative intensity and for a hedge portfolio with shares bought at high intensity and sold in shares with low investment in R&D in relation to market value. Panel A presents the coefficients and t statistics in parentheses of the equally weighted portfolios; and in Panel B, the portfolios determine

Table 7
Risk-adjusted returns of portfolios sorted by R&D expenditure/Equity Market Value.

	Innovative Intensity = R&D/MV				
	High	Medium	Low	High–low	Without R&D
Panel A: equally weighted portfolios					
Intercept	−0.780 (−1.664)*	−0.780 (−1.581)	−0.369 (−0.632)	−0.411 (−1.062)	−0.535 (−0.839)
MKT	0.205 (5.810)***	0.252 (5.722)***	0.187 (3.142)***	0.017 (0.394)	0.269 (4.612)***
SMB	0.497 (3.303)***	−0.132 (−0.918)	0.026 (0.171)	0.471 (3.321)***	0.477 (2.915)
HML	0.007 (0.062)	−0.013 (−0.121)	0.051 (0.567)	−0.044 (−0.378)	−0.057 (−0.459)
Panel B: value–weighted portfolios					
Intercept	−0.950 (−1.763)*	−0.956 (−1.394)	−0.475 (−0.615)	−0.474 (−0.669)	−0.617 (−1.107)
MKT	0.180 (5.192)***	0.291 (4.751)***	0.210 (2.852)***	−0.030 (−0.492)	0.222 (3.962)***
SMB	0.081 (0.483)	−0.558 (−3.088)***	−0.140 (−0.687)	0.221 (1.190)	0.096 (0.585)
HML	−0.128 (−0.984)	−0.338 (−1.565)	−0.167 (−1.423)	0.039 (0.240)	−0.130 (−1.241)

***, ** And * indicate significance at the level of 1%, 5%, and 10%, respectively.

Table 8
Return of the risk-adjusted portfolios classified by R&D expenditures/sales.

	Innovative Intensity = R&D/sales				
	High	Medium	Low	High–low	Without R&D
Panel A: equally weighted portfolios					
Intercept	−0.772 (−1.558)	−0.589 (−1.232)	−0.560 (−0.938)	−0.212 (−0.540)	−0.535 (−0.839)
MKT	0.218 (5.045)***	0.211 (6.006)***	0.215 (3.526)***	0.002 (0.070)	0.269 (4.612)***
SMB	0.394 (2.545)***	−0.020 (−0.147)	0.025 (0.155)	0.369 (2.814)***	0.477 (2.915)***
HML	−0.097 (−0.901)	0.088 (0.824)	0.072 (0.765)	−0.169 (−1.311)	−0.057 (−0.459)
Panel B: value–weighted portfolios					
Intercept	−0.630 (−0.934)	−0.938 (−1.364)	−0.967 (−1.151)	0.337 (0.596)	−0.617 (−1.107)
MKT	0.288 (4.632)***	0.257 (4.427)***	0.246 (2.921)***	0.043 (0.906)	0.222 (3.962)***
SMB	−0.247 (−1.152)	−0.724 (−4.170)***	−0.060 (−0.270)	−0.188 (−1.029)	0.096 (0.585)
HML	−0.389 (−2.437)**	−0.374 (−1.540)	−0.100 (−0.815)	−0.289 (−1.712)*	−0.130 (−1.241)

***, ** And * indicate significance at the level of 1%, 5%, and 10%, respectively.

the participation of each stock by its market value. The *t* statistic was calculated based on the standard error using the methodology of Newey and Kenneth (1987) for the correction of heteroskedasticity and serial autocorrelation.

For all portfolios, the market factor is highly significant and, consequently, the hedge portfolio has no exposure to this risk factor. Thus, the results indicate that the level of R&D expenditure does not influence a firm's exposure to systematic risk, for both equally weighted portfolios and for those value-weighted.

The SMB factor proved significant in explaining the returns of portfolios with high innovative intensity for equally weighted portfolios, just like the hedge portfolio, which also had exposure to this risk factor. When the value-weighted portfolio was considered, its significance disappeared in the more intensive portfolios and, thus, in the hedge portfolio.

The HML factor was not significant in any of the portfolios, including those that reported no investment in R&D in the period (no R&D).

Except for portfolios with higher levels of investment in R&D, all others showed no significant excess returns in the period. With regard to the portfolios of high intensity, the excess returns were negative and significant at 10%, indicating that these portfolios seem overvalued. These results are consistent with those found by Fernandes et al. (2013), when the authors identified a significant negative relationship between investment in R&D and the value of firms in Brazil between 2007 and 2009.

This result can be explained by the importance of investment in intangible assets obtained mainly from specialized media on the subject, linking investment in innovation to future success. Thus, companies that reported higher investments in R&D may have been overvalued due to the expectations created regarding their intangible investments. We also recognize that it is possible that the delay of six months between the formation of the portfolio and calculation of returns may not be sufficient to capture the effects of investment in R&D. However, the previous tests indicated no association between intensity of R&D and future returns.

It is noteworthy however, that although not statistically significant, all other portfolios also experienced negative excess returns. In addition, the hedge portfolio also showed no significant intercept, indicating no excess return from more intensive firms in relation to lower innovative intensity.

Table 8 presents Fama and French regressions (1993) for R&D/sales portfolios. As for portfolios classified according to R&D/MV, R&D/sales differences in load magnitudes of the SMB factor are significant, indicating that size is a significant risk factor in the pricing of firms investing in innovation. This is because this factor revealed itself as meaningful in the hedge portfolio, but not for companies who reported no expenditures in R&D in the period.

It should be emphasized, however, that the results for the portfolios categorized as R&D/sales reinforce the absence of abnormal risk-adjusted returns for innovative companies, as can be seen in Table 8, where the intercepts of all portfolios exhibit no significant loads.

5. Conclusions

In this study, we evaluated whether companies with greater R&D intensity have better future performance and whether such performance is priced by the brazilian capital market.

The results obtained indicate that companies that are more R&D intensive have better future performance, even after controlling for the effects of investment in tangible assets, marketing expenditures, the persistence of operating performance, and the average profitability reversion.

However, through the formation of buy and hold portfolios, we observed that this superior performance is not reflected in higher future returns. Even after calculating excess returns from companies of similar size and book to market equity, companies that are more R&D intensive did not show a difference relative to companies with less innovative intensity. These results were confirmed by cross-sectional regressions, where, after controlling for size and book-to-market values, the intensity of R&D, measured by both variables, was not significant in explaining returns, indicating that investors price adequately or do not distinguish between more or less innovative companies.

It is noteworthy, however, that the greater importance given to intangible assets in recent years, and the consequent greater importance for companies disclosing their investments in innovation, seem to be reflected in the performance of more R&D intensive companies in the long run. By excluding the portfolio formed in 2005, when only 17 companies reported investments in R&D and the portfolio showed high concentration, there was greater long-term returns (in the third year after the formation of the portfolio) among more intensive companies, consistent with the characteristics of R&D projects, which usually have longer maturity.

The results of the Fama and French regressions (1993) confirm the absence of abnormal risk-adjusted returns for the period evaluated. Controlling for the SMB and HML factors, almost all portfolios showed no excess returns, except for the more intensive portfolios when classified by R&D/MV, which showed significant negative excess returns, indicating an overpricing of these portfolios. However, the formation of a hedge portfolio, long in high intensity shares and short in low intensity, shows no abnormal returns, even when classified by R&D/MV, confirming the results found in the cross-sectional regressions.

Thus, we can conclude that the results found suggest that the R&D intensity is not relevant information in asset pricing for the period under analysis in Brazil. However, it is likely that not all companies show the same efficiency in the formation of intangible assets and thus the classification of companies by a metric of innovative intensity does not coincide with a measure of efficiency, which is able to highlight those companies that are most successful in achieving benefits from investments in R&D. Therefore, for future research, it is suggested that the tests performed in this study should be reproduced by means of efficiency variables rather than intensity measures, such as generating patents in relation to R&D expenditures or deriving a percentage of revenue from new products or services per unit of R&D expenditure, among others, assuming they are able to measure how efficient a company is in the formation of its intangible assets.

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