Financial Performance Feedback and R&D: A Comparison of Different Models

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ABSTRACT

Purpose: Performance feedback either supports or undermines a firm's current strategy. R&D is one of the most favoured proxies for a firm's response to performance feedback and this relation complements the commonly studied influence of innovation (R&D) on a firm's performance with a backward loop. The performance feedback literature works with a number of models used to empirically test these propositions and this study aims to compare the most common measures and models to locate potentially preferred alternatives for further research.

Methodology/Approach: The research uses panel data with 1,558 observations. The sample consists of 208 US stock exchange listed firms followed over the years 2001-2015.

Findings: The research suggests that models with separate historical and social aspirations may yield a slightly better fit with the data. However, the findings also indicate differences among R&D related dependent measures and their implications for empirical research. These differences arguably also reflect the underlying construct heterogeneity, therefore, researchers should work carefully with them to correctly explain their findings and provide results comparable to the previous literature.

Research Limitation/implication: The limitations of the research rose mainly from the limited number of performance factors studied, which stems from an emphasis on standard financial performance indicators.

Originality/Value of paper: The research contributes to the performance feedback literature by complementing a previous study that compared different aspiration models (Bromiley and Harris, 2014). By focusing on financial performance and R&D variables, the research offers the first concise entry point

for researchers considering empirical studies on financial performance feedback and R&D relationship.

Category: Research paper

Keywords: performance feedback; research and development; firm behaviour; financial performance

1 INTRODUCTION

Innovation is a valuable source of a firm's performance and competitive advantage. Numerous theoretical perspectives describe the relationship, e.g., a dynamic resource-based view (Helfat and Peteraf, 2003), and a number of empirical studies confirms this (e.g., Eberhart, Maxwell and Siddique, 2004; Lome, Heggeseth and Moen, 2016). On the other hand, one can assume that investment in innovation is a function of performance as well. The behavioral theory of the firm (Cyert and March, 1963) expects firms to respond to performance feedback by embracing change, i.e. acting innovatively if performance is unsatisfactory (Simon, 1955). Satisfactory performance means results that attain or exceed a firm's goal – aspiration. These aspirations are formed (Cyert and March, 1963) based on a firm's previous performance, representing historical aspiration, and the performance of a firm's group of peers, representing social aspiration. Attainment discrepancies are then differences between current performance and a given aspiration level. Logically they can be either negative (when a firm underperforms) or nil/positive (when a firm attains or exceeds its aspiration level). Eq. 1 shows this for *attainment historical discrepancy*, while Eq. 2 for *attainment social discrepancy*. The original formulation of aspirations by Cyert and March (1963) also contains a third variable which forms current aspirations – aspiration from a previous period as shown in Eq. 3 for attainment historical discrepancy. However, a previous aspiration is often omitted from the calculation (e.g. Bromiley and Harris, 2014) or has empirically marginal weight (such as 0.04 in the case of Greve, 2003).

$$Attainment\ historical\ discrepancy_{i,t} = Performance_{i,t} - Performance_{i,t-1}, \quad (1)$$

$$Attainment\ social\ discrepancy_{i,t} = Performance_{i,t} - \frac{\sum_{i=1}^{n} Performance_{i,t}}{n}, \quad (2)$$

$$Attainment\ historical\ discrepancy_{i,t} = Performance_{i,t} - \alpha * Aspiration_{i,t-1} - (1-\alpha) * Performance_{i,t-1}. \quad (3)$$

Where $Aspiration_{i,t-1} = \alpha * Aspiration_{i,t-2} + (1-\alpha) * Performance_{i,t-2}$.

Traditionally, empirical studies of performance feedback often use R&D expense or R&D intensity, i.e. R&D expense to sales, as dependent variables (for a review see Shinkle, 2012; or Posen, et al., 2017). R&D expense or R&D intensity can be considered proxies for both a search activity (R&D as a mean of looking for new strategic alternatives) and a result of this search (change in R&D as a decision to refocus the firm's competitive strategy). This combination is theoretically problematic (Posen, et al., 2017), yet it still leads to some interesting findings concering firms' behaviour (Shinkle, 2012; Posen, et al., 2017). Besides R&D, there are studies using performance feedback to explain a firm's behaviour in areas like mergers and acquisitions or divestments (e.g. Iyer and Miller, 2008; Kuusela, Keil and Maula, 2017) or new market entries (e.g. Ref and Shapira, 2017).

Over time, the performance feedback literature has produced an enormous variety of different approaches to the topic, which lead to an abundance of findings in the strength and degree of the relations (Washburn and Bromiley, 2012). Following on from Bromiley and Harris (2014), this study aims to complement and test their findings in the comparison of different aspiration models (aspiration representations), performance and outcome measures. Compared to the original study, this research tests a broader range of aspiration models, especially separate and switching, which Bromiley and Harris (2014) identify as the best fit for their data, as well as it uses different controls. On the other hand, the research has a slightly narrower focus on performance measures – focusing only on the main financial indicators – and on outcome measures with different forms of R&D expense, therefore empirically supporting Bromiley, Rau and Zhang's (2017) proposition that R&D expense should be perceived differently from R&D intensity.

The research contributes to the theory by complementing Bromiley and Harris's (2014) original findings. By focusing on various financial performance and R&D variables, it represents a summary and an entry point for researchers considering performance feedback research, especially for those who study traditional innovation to performance relationship. The practical value of this research lies in its contribution to the aspiration-/goal-setting literature. A knowledge of these mechanisms can be helpful for competitive intelligence or establishing management incentive systems.

2 METHODOLOGY

Aspiration models/representations. The research use three different models of aspiration formation: (i) the separate model which works with two different aspiration variables, one for historical aspiration and one for social aspiration (this representation is arguably the most prominent in the current performance feedback literature, recently used by e.g. Ref and Shapira, 2017); (ii) the switching model, which uses one aspiration variable, either historical or social depending on a switching rule selecting the higher value of two aspirations, i.e.

assuming that a firm strives to be at least on a social aspiration level when its historical aspiration level is lower than it; (iii) the weighted-average model, which uses one aspiration variable being (in the case of the research) the simple average of historical and social aspirations. Besides these, both separate and switching models take three variants: (a) basic; (b) containing historical aspiration scaled by 5%, which represents striving for better behaviour assumed by some authors (e.g. Bromiley, 1991); (c) having a previous aspiration ruled in as shown in Eq. 3. As stated in the Introduction, the previous studies have usually omitted past aspiration or show that it has only marginal weight, however, for comparison and robustness, the main research model is also recalculated using this approach with a relatively high weight of 30% (using the smaller weight closer to 4% of Greve, 2003, does not make much sense as that would lead to results that are almost identical to the basic models). The study only introduces a weighted-average model in its basic variant because of unfavourable properties leading to unlikely firm behaviour over different aspiration levels (Bromiley and Harris, 2014).

Table 1 – Three Pillars of Performance Feedback

Aspiration models (Aspiration representations)	**Performance measures**	**Outcome measures**
Separate model Two separate measures for historical and social aspirations Variant A: Basic model Variant B: Historical aspiration scaled by +5% Variant C: Aspirations contains 30% of a previous aspiration level Switching model? Contains switching variable determining change in focus from historical to social aspiration and vice versa Variant A: Basic model Variant B: Historical aspiration scaled by +5% Variant C: Aspirations contains 30% of a previous aspiration level Weighted-average model: One aspiration measure - equal-weighted average of historical and social aspiration	Net Income ROA (Return on assets) = EBIT / Total assets ROE (Return on equity) = EBIT / Total equity ROS (Return on sales) = EBIT / Total Sales Profit Margin = Net Income / Total Sales	R&D expense R&D expense change = Year-on-year change in R&D expense R&D intensity = R&D expense / Total Sales R&D intensity change = Year-on-year change in R&D intensity

Dependent variables (outcome measures). The study uses all four traditional outcome measures revolving around Research and Development: (i) R&D

expense; (ii) R&D expense change; (iii) R&D intensity; and (iv) R&D intensity change. Their calculations are described in Tab. 1.

Performance feedback variables (performance measures). Five financial indicators serve as financial measures: (i) net income; (ii) return on assets, ROA; (iii) return on equity, ROE; (iv) return on sales, ROS; and (v) profit margin. Their calculations are described in Tab. 1. These five measures mostly come from Bromiley and Harris (2014) and represent the most widely used performance measures from the behavioral theory of the firm literature which are based on firms' financial accounts.

Control variables. Control variables are identical in all the models included in this research. To account for a firm's size effect and its change, the research includes two measures of sales: (i) the natural logarithm of a particular year's sales and, (ii) the change in sales from the previous year. Sales change, especially, is an important addition compared to controls employed by Bromiley and Harris (2014) as R&D is often tied on a certain level to a firm's sales. Additionally, slack search (Cyert and March, 1963) results from a firm having abundant resources that are used for experimentation, which can result in an increase in R&D expense that is not related to performance feedback. To account for the influence of slack resources, the models contain measures for (iii) available slack and (iv) potential slack. The construction of two measures is similar to the research by Marlin and Geiger (2015), the difference is in grouping the variables into two. Available slack consists of the sum of the current ratio (current assets on current liabilities), a quick ratio (current assets minus inventories on current liabilities) and working capital (current assets minus current liabilities on sales). Potential slack consists of the sum of debt to equity, debt to sales and debt to assets.

2.1 Data

The sample used for the research consists of stock-exchange-listed firms from the industrial sector (GICS code 20) domiciled in the United States followed from 2001 to 2015. The data originates from the Bloomberg database. Numerous firms have been omitted from the sample in certain years or completely because they were not listed/did not exist in the given years or did not reported a sufficient amount of data on R&D or other variables. The final sample is an unbalanced panel of 208 firms with 1,558 yearly observations.

To deal with the extremely outlying observations, both R&D expense change and R&D intensity change are capped at the maximum level of change of 100%, so that that higher changes are reduced to the 100% level. Corresponding R&D expense and R&D intensity observations, i.e. the given firm and given year, are scaled down by the same factor. For example, when a firm changes R&D expense from $10 million in year 1 to $50 million in year 2, it results in a 400% increase that is capped in the data at 100% R&D expense change and $20 million R&D expense, respectively. These transformed data are not used to compute the

following year base value (meaning that the original value of $50 million is used for computing the change in year 3).

The models are computed using fixed effects with robust (HAC) standard errors. The software used for estimation is gretl, version 2017b. Gretl is freeware for econometric data analysis developed mainly by Allin Cottrell from Wake Forest University and Riccardo Lucchetti from Università Politecnica delle Marche.

To compare the models against each other, the research adopts the approach of Bromiley and Harris (2014). This means that the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) of particular models serve as means of comparison. The lower the value for a given criterion, the higher the quality a model has when explaining this dependent variable using the sample data. However, it is important to note that small differences may not be statistically significant.

3 RESULTS

The values of information criteria for models with R&D expense as the outcome measure are reported in Tab. 2. In this case, models with net income as a performance measure clearly prevail in quality in both AIC and BIC. The other four performance measures show similar results to each other. In the case of aspiration representations, the separate models have apparently higher quality for net income, although overall there is no clear pattern giving preference to any of the aspiration representations.

Table 2 – Results of AIC and BIC for Models with R&D Expense as the Outcome Measure (Three Lowest Values Indicated in Bold)

	Outcome measure	Aspiration representation	Net Income	ROA	ROE	ROS	Profit Margin
AIC	R&D expense	Separate, var A	**19,848.4**	20,374.1	20,373.2	20,369.8	20,371.6
	R&D expense	Separate, var B	**19,840.2**	20,374.0	20,373.2	20,369.8	20,371.6
	R&D expense	Separate, var C	**19,799.3**	20,374.1	20,373.2	20,369.6	20,371.8
	R&D expense	Switching, var A	20,329.0	20,370.5	20,368.8	20,370.3	20,368.1
	R&D expense	Switching, var B	20,330.2	20,370.5	20,369.8	20,370.3	20,368.1
	R&D expense	Switching, var C	20,313.8	20,370.5	20,370.3	20,370.6	20,368.1
	R&D expense	Weighted 50	20,315.9	20,370.5	20,370.8	20,370.6	20,368.2
BIC	R&D expense	Separate, var A	**21,004.3**	21,529.9	21,529.1	21,525.7	21,527.4
	R&D expense	Separate, var B	**20,996.0**	21,529.9	21,529.1	21,525.7	21,527.4
	R&D expense	Separate, var C	**20,955.1**	21,530.0	21,529.0	21,525.4	21,527.6
	R&D expense	Switching, var A	21,474.1	21,515.7	21,514.9	21,515.4	21,513.3

	Outcome measure	Aspiration representation	Net Income	ROA	ROE	ROS	Profit Margin
	R&D expense	Switching, var B	21,475.4	21,515.7	21,514.9	21,515.4	21,513.3
	R&D expense	Switching, var C	21,459.0	21,515.7	21,515.4	21,515.7	21,513.3
	R&D expense	Weighted 50	21,461.0	21,515.6	21,515.9	21,515.8	21,513.4

The values of information criteria for models with R&D expense change as the outcome measure are reported in Tab. 3. In this case, net income models are the least preferred of all the aspiration representation variants. The best performance measure for R&D expense change is, for this data set, return on sales. As for aspiration representations, AIC and BIC values do not consistently indicate any preferred variant.

Table 3 – Results of AIC and BIC for Models with R&D Expense Change as the Outcome Measure (Three Lowest Values Indicated in Bold)

	Outcome measure	Aspiration representation	Net Income	ROA	ROE	ROS	Profit Margin
AIC	R&D exp. change	Separate, var A	1,950.9	1,945.0	1,945.5	**1,938.1**	1,945.7
	R&D exp. change	Separate, var B	1,950.8	1,945.1	1,945.5	**1,937.6**	1,945.8
	R&D exp. change	Separate, var C	1,950.6	1,942.1	1,945.5	**1,937.8**	1,948.4
	R&D exp. change	Switching, var A	1,945.8	1,944.3	1,944.4	1,944.0	1,944.9
	R&D exp. change	Switching, var B	1,945.6	1,944.2	1,944.5	1,944.0	1,944.9
	R&D exp. change	Switching, var C	1,945.9	1,942.8	1,942.9	1,938.6	1,944.9
	R&D exp. change	Weighted 50	1,947.1	1,946.2	1,945.9	1,939.1	1,945.2
BIC	R&D exp. change	Separate, var A	3,106.7	3,100.9	3,101.3	3,093.9	3,101.6
	R&D exp. change	Separate, var B	3,106.7	3,100.9	3,101.3	3,093.5	3,101.6
	R&D exp. change	Separate, var C	3,106.5	3,097.9	3,101.4	3,093.6	3,104.3
	R&D exp. change	Switching, var A	3,091.0	3,089.4	3,089.5	3,089.2	3,090.1
	R&D exp. change	Switching, var B	3,090.8	3,089.4	3,089.6	3,089.2	3,090.1
	R&D exp. change	Switching, var C	3,091.1	**3,088.0**	3,088.1	**3,083.7**	3,090.0
	R&D exp. change	Weighted 50	3,092.2	3,091.4	3,091.0	**3,084.2**	3,090.4

The values of information criteria for models with R&D intensity as the outcome measure are reported in Tab. 4. AIC and BIC are the most distinguishable across all outcome measures with profit margin having the best values. The second best performance measure is ROS, with the rest being quite similar. For ROA, ROS and profit margin, separate aspiration representations yields a better fit with the

data. This does not hold for net income and ROE, where AIC and BIC are similar.

Table 4 – Results of AIC and BIC for Models with R&D Intensity as the Outcome Measure (Three Lowest Values Indicated in Bold)

	Outcome measure	Aspiration representation	Net Income	ROA	ROE	ROS	Profit Margin
AIC	R&D intensity	Separate, var A	7,526.2	7,482.9	7,523.5	7,202.2	**7,030.8**
	R&D intensity	Separate, var B	7,526.2	7,483.9	7,523.4	7,187.6	**7,039.0**
	R&D intensity	Separate, var C	7,526.2	7,508.2	7,525.9	7,086.5	**7,051.9**
	R&D intensity	Switching, var A	7,523.0	7,521.6	7,522.9	7,361.0	7,254.9
	R&D intensity	Switching, var B	7,523.0	7,521.6	7,522.9	7,361.0	7,255.3
	R&D intensity	Switching, var C	7,522.9	7,521.5	7,522.9	7,358.8	7,252.3
	R&D intensity	Weighted 50	7,523.0	7,513.1	7,523.0	7,146.7	7,324.9
BIC	R&D intensity	Separate, var A	8,682.1	8,638.7	8,679.3	8,358.0	**8,186.6**
	R&D intensity	Separate, var B	8,682.1	8,639.8	8,679.3	8,343.5	**8,194.8**
	R&D intensity	Separate, var C	8,682.1	8,664.0	8,681.7	8,242.3	**8,207.7**
	R&D intensity	Switching, var A	8,668.1	8,666.8	8,668.1	8,506.2	8,400.1
	R&D intensity	Switching, var B	8,668.1	8,666.8	8,668.1	8,506.2	8,400.5
	R&D intensity	Switching, var C	8,668.1	8,666.7	8,668.0	8,504.0	8,397.5
	R&D intensity	Weighted 50	8,668.1	8,658.2	8,668.1	8,291.8	8,470.0

The values of information criteria for models with R&D intensity change as the outcome measure are reported in Tab. 5. In this case, models with ROA and ROS as performance measures show the lowest value in both AIC and BIC. As for aspiration representations, the weighted-average and switching models seems slightly preferable compared to the separate models.

Table 5 – Results of AIC and BIC for Models with R&D Intensity Change as the Outcome Measure (Three Lowest Values Indicated in Bold)

	Outcome measure	Aspiration representation	Net Income	ROA	ROE	ROS	Profit Margin
AIC	R&D int. change	Separate, var A	4,512.2	4,505.3	4,511.9	4,509.8	4,511.9
	R&D int. change	Separate, var B	4,512.2	4,505.1	4,511.9	4,509.8	4,511.2
	R&D int. change	Separate, var C	4,512.1	4,508.0	4,512.1	4,510.1	4,510.8
	R&D int. change	Switching, var A	4,508.4	4,505.8	4,508.7	**4,504.3**	4,509.0

	Outcome measure	Aspiration representation	Net Income	ROA	ROE	ROS	Profit Margin
	R&D int. change	Switching, var B	4,508.4	4,505.7	4,508.8	**4,504.4**	4,509.0
	R&D int. change	Switching, var C	4,508.4	4,506.2	4,508.5	4,508.9	4,509.0
	R&D int. change	Weighted 50	4,508.3	**4,503.8**	4,508.6	4,508.3	4,508.7
BIC	R&D int. change	Separate, var A	5,668.0	5,661.2	5,667.7	5,665.6	5,667.0
	R&D int. change	Separate, var B	5,668.0	5,661.0	5,667.7	5,665.6	5,667.1
	R&D int. change	Separate, var C	5,668.0	5,663.8	5,668.0	5,665.9	5,666.6
	R&D int. change	Switching, var A	5,653.6	5,650.9	5,653.9	**5,649.5**	5,654.2
	R&D int. change	Switching, var B	5,653.6	5,650.9	5,653.9	**5,649.6**	5,654.2
	R&D int. change	Switching, var C	5,653.6	5,651.3	5,653.6	5,654.1	5,654.2
	R&D int. change	Weighted 50	5,653.1	**5,648.9**	5,653.7	5,653.4	5,653.8

4 DISCUSSION

Before making a comparison with the findings of Bromiley and Harris (2014), it is worth discussing the results in detail and pointing out some interesting patterns. When considering the results of R&D expense as the outcome measure, the dominance of net income compared to the others can be attributed mainly to the fact that it is the only financial measure that is not scaled. On its own, R&D expense should be theoretically considered as the least appropriate fit for the behavioral theory of the firm out of the four outcome measures. Compared to change measures, it is left censored as it cannot turn to negative values. Compared to R&D intensity, it does not control for firm size by itself. Moreover, as large firms ought to have higher R&D budgets than their smaller counterparts, differences resulting from performance feedback empirically play a marginal role compared to the absolute values of R&D expense.

What is interesting for both the change outcome measures is that the differences in the information criteria are quite small across all the models. This might be the result of having similar financial measures; all five performance measures use some kind of profit of the firm. Therefore, a firm responding to performance feedback in the case of ROA underperformance statistically responds to other profit-tied measures as well (as ROA underperformance probably leads to underperformance in ROE, ROS etc.). It might be interesting to compare the results with more distinct performance measures, either generic ones such as stock market returns (Bromiley and Harris, 2014) or more industry or firm specific (audience share, Greve, 1998; game score, Lehman, et al., 2011). Such a comparison could either support or reject research findings from a slightly different perspective.

In the case of R&D intensity, performance measures scaled to sales show the best fit. The most obvious explanation lies in the fact that R&D intensity stands for R&D expense relative to sales – meaning that sales play an important role in setting and changing the intensity. Resulting from the personal interviews conducted by the researcher, it is common practice in the industry to anchor R&D expense to sales. This makes R&D investment highly sensitive to the sales performance of a firm. A similar situation is in the R&D intensity change models (at least for ROS), although in this case, the differences are relatively small. Compared to the findings of Bromiley and Harris (2014) who only studied R&D intensity, this study confirms their preference for separate aspiration models. However, in the case of performance measures, the research points to totally different results. Their models favorize net income which is rather surprising if we take into account that the dependent variable itself is scaled. Although empirically plausible because of their use of fixed effect models, which rule out interfirm variance (Certo, Withers and Semadeni, 2017), such result has certain real life drawbacks. A change in net income can be the result of numerous factors other than a change in performance, e.g. acquisitions or divestitures of anything from a single product up to a business unit or a division. Although such activities may and probably will result in a change in R&D expense, it is hard to consider them to be the sole reason for a change in R&D intensity. However, one can still not rule out other behavioural factors such as investors considering net income as an important financial measure worth a year-on-year or industry comparison (despite all its drawbacks and possibilities for masking accounting based performance or even its manipulation, Gunny, 2010) and managers responding to their worries. Nevertheless, in the case of this study, net income has apparently shown the least appropriate fit across all the models for R&D intensity.

It is not surprising that the variants A, B and C from both the separate and switching aspirations have similar results. For example, increasing aspiration by a factor of 1.05 (as in Bromiley, 1991) from the previous year's performance leads to a 2-6% decrease in the overall success rate in attaining aspirations in the study's sample. Similarly, firms have relatively stable financial performance which makes previous aspiration an unimportant factor. Although in some cases deviations from the basic model play a certain role in the resulting AIC and BIC, the values are mostly very much the same. This means that other factors are more important than this aspiration.

The differences in the resulting quality of separate vs switching/weighted-average models can be partially explained by the fact that separate models contain two aspiration related variables (i.e. separate historical and social attainment discrepancies) compared to one in the cases of switching and weighted-average models. Although both information criteria discriminate the higher number of independent variables, the approach is general and by its nature cannot filter any detail. Nevertheless, for this research, this is not considered to be a particularly limiting factor, especially as for some outcome

measures, the separate models show lower values of information criteria, while a few others have higher values.

Although the research suggests some preference for models, it also indicates that there is no silver bullet to solve all the questions. The dependent variable in performance feedback equations plays a crucial role in determining which models are preferable. This study is limited by the sheer number of such variables (Posen, et al., 2017), however its value lies in pointing to particular properties of the individual pillars of performance feedback. Even related variables like R&D expense and R&D intensity measure slightly different constructs (Bromiley, Rau and Zhang, 2017) which lead to a different level of support for particular measures of performance feedback. Also, as differences with Bromiley and Harris's (2014) study highlight, the findings are also sample dependent. Although the cumulative evidence supports some of the findings, more replicative research is needed.

5 CONCLUSION

Over the last three decades, a huge variety of different measures and models for a firm's aspiration has amassed in the empirical research into performance feedback. This variety brings both advantages regarding the findings and disadvantages in the limited comparability of the results. In addition, the sheer number of alternatives makes it difficult to make the appropriate choices. All this leads to the need for research comparing a higher number of these alternatives. This research aims to compare performance feedback models focused on R&D outcome measures and financial performance. The findings support the previous preference for separate aspiration models, nevertheless, it primarily points to differences in alternative dependent R&D variables which make a general recommendation for specific measures and model combinations impossible. Future researchers should take these findings into consideration and reflect upon them when preparing contributions which will be comparable across the literature.

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