The Effect of Prior-Period Sales Changes on Cost Behavior

Rajiv D. Banker
The Fox School of Business
Temple University
Philadelphia, PA 19122
banker@temple.edu

Mustafa Ciftci
School of Management
The University of Texas at Dallas
Richardson, TX 75083-0688
mxc012400@utdallas.edu

Raj Mashruwala
Olin School of Business
Washington University in St. Louis
St. Louis, MO 63130-4899
mashruwala@wustl.edu

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Abstract

Anderson, Banker and Janakiraman (2003) (hereafter ABJ) document asymmetric cost behavior in selling, general and administrative costs conditioned on the direction of contemporaneous sales changes. They show that costs decrease less when activity levels decline than they rise when activity levels increase and they refer to this as the ‘sticky’ behavior of costs. They argue that this behavior is largely driven by managers’ perceptions of the likelihood of demand reversal in the future. In this paper we argue that when managers make activity resource capacity decisions they also consider surplus capacity that has been inherited from the past. This makes it important to include the effect of prior period sales changes in any such analyses of cost behavior.

Theoretical analysis of rational behavior of managers based on inherited surplus capacity suggests that when we condition based on a sales decrease in the previous year the results of ABJ are, in fact, reversed. The decrease in costs when sales decline for a second consecutive year should be larger than the increase in costs when sales increase reversing a decline in sales in the prior year. Empirical estimation of the model used by ABJ while conditioning based on sales changes in the prior period supports this theoretical analysis. The ABJ results only hold given a sales increase in the previous year and are reversed given a sales decrease in the previous year. This important contingent result is masked in the unconditioned ABJ analysis by the predominance of observations with sales increases in the prior year.
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1. Introduction

The traditional view of cost behavior has been that costs are either fixed or variable with respect to changes in volume. This view holds that changes in costs are driven solely by the magnitude of change in the cost driver. The direction of change in the cost driver has no role to play in this model. In their paper, Anderson, Banker and Janakiraman (2003) (hereafter referred to as ABJ) investigate whether the actual behavior of costs differs from the traditional view of costs being simply fixed or variable with respect to changes in activity levels. ABJ argue that managers act rationally to maximize expected profits and based on their perceived likelihood of reversal of demand decline, managers trade off the costs of reducing capacity with the costs of maintaining excess capacity. ABJ present evidence showing that when sales decrease in the current period, costs decrease less than proportionately compared to when sales increase in the current period. While explaining their results ABJ reason that managers will maintain slack capacity if they expect demand to increase in the future, rather than incur adjustment costs immediately when sales volume declines. Thus, their model takes an important step forward in understanding cost behavior relative to the common cost accounting assumption that costs are driven only by the magnitude of changes in the cost driver, but not by the direction of change in the cost driver. Extending the ABJ model, Balakrishnan et al. (2004) show that other factors such as the magnitude of the changes in activity levels and the levels of capacity utilization may also influence the proportionality of the cost response.
In this paper, we argue that it is not enough to just look at the direction of contemporaneous changes in the cost driver; it is important to also include the direction of prior-period sales changes when analyzing cost behavior in the current period. In making their arguments for sticky cost behavior, ABJ focus on managers’ expectations of the future reversal of a sales decline as the driving force behind current period decisions. Managers, though, make decisions based on what has occurred in the past, as well as what they expect in the future. In addition to expectations about the future, the surplus capacity that is inherited from the past period also plays an important role in managers’ decisions regarding augmenting or reducing activity resource capacity\(^1\) in the current period.

Our objective is to provide empirical evidence that helps further the development of a theoretical framework to understand the reasons for the asymmetry in cost behavior. Including the inherited slack capacity in the analysis is likely to change the conclusions that can be drawn about cost behavior. If, for instance, sales decreased in the prior period then there is likely to be surplus capacity available in the current period. Hence, if sales were to increase in the current period, then this surplus capacity could be used to meet the increase in demand and costs would not need to increase as much. On the other hand, if sales were to decrease in the current period after having also decreased in the prior period, then managers will be strongly motivated to reduce capacity since there will be surplus capacity available from two consecutive periods of sales decrease. Also, having witnessed two consecutive periods of sales decrease, managers will be less sanguine

\(^1\) In the accounting literature, capacity resources involve making up-front cost commitments, while resource capacity is the maximum use of those resources in performing activities, and capacity costs refer to the spending on those resources (see Banker and Hughes, 1994; Balachandran, Balakrishnan and Sivaramakrishnan, 1997; Balakrishnan and Sivaramakrishnan, 2002).
about this trend reversing in the future and hence be more willing to reduce capacity. In this situation, then, we are likely to find exactly the opposite result of ABJ. ABJ argue that costs will decrease less for a proportionate decrease in current period sales than they would increase for a proportionate increase in current period sales. In fact, given a decrease in prior period sales, we predict a greater decrease in costs for a proportionate decrease in current period sales compared to an increase in costs for a proportionate increase in current period sales.

We examine this theoretical prediction by explicitly conditioning the ABJ model on what has occurred in the prior period. In the sample used by ABJ, there is a higher frequency of observations when sales increased in the previous year than when sales decreased in the previous year. Thus, their analysis masks the possibility that for firms whose sales decreased in the previous year, the results could be very different. Our empirical findings in this paper confirm this notion. In fact, when we condition the ABJ results on direction of sales change in the previous year, we find that the results of ABJ are reversed.

This theoretical analysis of cost behavior based on slack capacity and expected sales trends also results in predictions about the magnitude of relative cost changes that are predicated on the direction of prior period sales changes. Our empirical findings confirm the predictions that the relative magnitude of an increase (a decrease) in sales for a given increase (decrease) in current period sales is greater when there was a sales increase (decrease) in the prior period than when there was a sales decrease (increase) in the prior period. This underscores the importance of considering the direction of prior-period sales changes in developing a theory of cost behavior.
The rest of the paper proceeds as follows. Section 2 presents the theoretical considerations that motivate and develop our hypotheses related to the asymmetric behavior of costs. Section 3 describes the empirical models used to test our hypotheses and section 4 provides a discussion of the empirical results. Section 5 concludes with a summary of the main findings of the paper and their managerial implications.

2. Prior-Period Sales Changes and Cost Behavior

Examining cost behavior has important implications for managers making decisions as well as for understanding and predicting firm performance. The traditional model of cost behavior has been to treat costs either as fixed (and step-fixed) or variable costs, based on whether they vary with volume or some other cost driver. Several studies (notably, Callen, 1991, Callen, et al., 1998, Noreen and Sorderstrom, 1994, 1997) discuss the limitations of models of cost behavior that are based on the assumption of a linear cost structure. ABJ’s analysis highlighted a major deficiency of the traditional model. The traditional model assumes that there is a direct functional relationship between costs and volume (or cost driver); for every volume level there exists a unique cost level. This model omits an essential aspect of how costs arise. Costs are not incurred automatically. Managers must decide how much activity resource capacity to provide, and it is that decision that results in the costs being incurred. A theoretical analysis of costs, therefore, must consider the incentives and information driving the managers’ capacity decisions (Zellner, Kmenta and Dreze, 1966). In this study we aim to extend this line of research by explicitly incorporating decisions made by managers that result in discrete nonlinear shifts in the cost function even when the underlying cost structure remains linear.
ABJ documented that the direction of sales change in the current period also matters – costs increase more when sales revenue increases than they fall when sales revenue decreases. The theoretical basis for ABJ’s hypothesis is that when sales decrease, managers will choose to maintain some slack capacity rather than reduce capacity to the level required for current sales volume. This is because managers consider the adjustment costs that must be incurred when capacity is decreased. Also, if they cut resource capacity due to a decline in demand and demand reverses in the following period, they will have to replenish capacity eliminated in the prior year. If, instead, they choose to maintain unused resource capacity, they will bear the cost of carrying slack capacity. Thus, managers trade off the costs associated with carrying slack capacity against the adjustment costs which must be incurred to add resources if demand reverses in the next period. Therefore, managers’ assessment of probability of demand reversal will also affect their decision of whether to reduce resource capacity in the current period when facing a decline in sales. ABJ also posit that if the direction of sales change in the current period is the same as that in the previous period, then it is more likely that managers will infer that this trend will persist in the future. This will affect their posterior beliefs about the probability of reversal in the direction of sales change and their evaluation of the trade-off between the cost of holding surplus capacity and the cost of reducing surplus capacity in the current period and ramping up in case sales increase.

A missing piece in the theoretical development of the decision-making process described above is that the decision to add or reduce capacity in the current period will also be affected by the availability of slack capacity inherited from the previous period. Thus, in addition to the direction of sales change in the current period considered in ABJ,
the direction of sales change in the prior period is also important to consider. If sales had
decreased in the previous period, it is likely that managers would have chosen then to
maintain slack capacity due to potential adjustment costs. This unused capacity can be
used in the current period to meet some of the increase in demand if sales increase now.
Therefore, under this scenario of a sales decrease in the previous period, costs will
decrease more when sales decreases in the current period than costs will increase when
sales increases in the current period. Thus, while the ABJ results will hold when we
consider an increase in sales in the prior period, the results will be reversed when sales
have decreased in the prior period. This underscores the importance of considering the
direction of sales change in the prior period when considering cost behavior.  

In this paper we consider the theoretical implications of both these factors that
could affect the magnitude of variation in SG&A costs: the probability of demand
reversal and the likely availability of slack capacity. We examine if there is asymmetric
cost behavior while conditioning based on sales changes in the prior year by considering
two consecutive periods of firms’ revenue and SG&A costs. The four possible scenarios
are depicted in figure 1.

We begin by considering the ABJ results based on the direction of sales change in
the prior period. Managers assess the likelihood of demand reversal in the future based on
the trends in sales revenue in years $t$ and $t-1$. Consider the two cases when sales increased
in the previous period (i.e. Case-($I_t, I_{t-1}$) and Case-($D_t, I_{t-1}$)). In the first case, two

\footnote{In their hypothesis 3A, ABJ consider the effect of successive decreases in sales revenue on cost stickiness. They argue that stickiness will be lower when sales also declined in the preceding period compared to when sales increased in the prior period because managers’ assessment of the permanence of demand reduction is likely to get stronger as a revenue decline continues. Thus, they compare Case-($D_t, D_{t-1}$) with Case-($D_t, I_{t-1}$) as we do later in hypothesis 4. ABJ do not compare cases ($I_t, I_{t-1}$) and ($D_t, I_{t-1}$) as in our principal hypothesis 1, or cases ($I_t, D_{t-1}$) and ($D_t, D_{t-1}$) in hypothesis 2.}
consecutive periods of sales increase will lead to managers assessing a higher probability of continuing sales increase. On the other hand, if sales increased in the prior period but reversed in the current period, then managers will maintain slack capacity in the expectation that the demand conditions are transient and likely to reverse in the future. Thus, we expect to find the same result as ABJ when we condition the analysis given an increase in sales revenue in the previous period.

*Hypothesis 1: Given an increase in sales in the previous period, the relative magnitude of an increase in SG&A costs for an increase in sales in the current period is greater than the relative magnitude of a decrease in SG&A costs for a decrease in sales in the current period.*

This situation is reversed, though, when we condition based on a decrease in sales in the previous period (Case-(I, D_{t-1}) and Case-(D, D_{t-1})). If sales decreased in the prior year, then there is likely to be surplus capacity inherited from the prior period that is now available in the current period. This surplus capacity can, at least partially, cover any increases in demand in the current period. On the other hand, if demand decreases in the current period also, then managers may be inclined to get rid of excess capacity since two consecutive periods of sales decline may reinforce the likelihood of lower sales. This suggests that given a sales decrease in the prior period, the ABJ result is likely to be reversed.

*Hypothesis 2: Given a decrease in sales in the previous period, the relative magnitude of a decrease in SG&A costs for a decrease in sales in the current period is greater than the relative magnitude of an increase in SG&A costs for an increase in sales in the current period.*
Theoretical consideration of the implications of the slack capacity maintained in the prior period thus implies that while the ABJ results are likely to hold when sales increase in the prior period, they are likely to be reversed when sales decrease in the prior period.

Our second set of hypotheses draws on this theoretical consideration to explicitly examine the magnitude of sales change in the current period based on the direction of sales change in the prior period. We consider two cases: first when sales revenue increases in the current period and second when sales revenue decreases in the current period. The theoretical arguments used to motivate hypotheses 1 and 2 will also hold when we consider the magnitude of change in the current period based on the direction of sales change in the prior period. When sales increases in both the current year as well as the previous year, managers will be more confident about the persistence of the demand increase than when the current period sales increase was preceded by a sales decrease in the prior period. Also, when there has been a decrease in sales in the previous year there will be surplus capacity available to meet some or all of the increase in the demand in the current period. Thus, we expect that the proportionate increase in costs will be higher in Case-(I, I,t−1) than the increase in costs in Case-(D, I,t−1).

Hypothesis 3: The relative magnitude of an increase in SG&A costs for an increase in sales is greater when there was a sales increase in the prior period than when there was a sales decrease in the prior period.

When sales decrease in the current period, we also expect that the magnitude of the change in costs will depend on the direction of sales change in
the prior period. In Case-(D_t D_{t-1}) there will be more slack capacity available than in Case-(D_t I_{t-1}). Managers will be motivated to reduce resource capacity when more capacity is slack with two consecutive periods of sales decreases. Moreover, managers will view two periods of sales decreases as a signal that this demand trend will persist in the future, making them more confident about reducing resource capacity. Therefore we expect that costs will decrease more in Case-(D_t D_{t-1}) than in Case-(D_t I_{t-1}).

**Hypothesis 4:** The relative magnitude of a decrease in SG&A costs for a decrease in sales is greater when there was a sales decrease in the prior period than when there was a sales increase in the prior period.

Our four hypotheses comparing the relative magnitudes of the change in SG&A costs for a given change in sales are summarized in figure 2.

3. **Empirical Model**

The empirical model to test our hypotheses estimates the magnitude of variation in SG&A costs with respect to contemporaneous variations in sales. Extending the ABJ analysis, the model to test hypotheses 1 through 4 can then be constructed as follows:

**Model A:**

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\log \left( \frac{SG & A_{i,t}}{SG & A_{i,t-1}} \right) = \beta_0 + \beta_1 \log \left( \frac{REV_{i,t}}{REV_{i,t-1}} \right) + \beta_2 \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log \log 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where REV is the sales revenue (data 6 in Compustat); and SG&A is sales, general and administrative costs (data 189 in Compustat) for firm i. We include three dummy variables to distinguish each situation in terms of the direction of change in SG&A costs in current and prior periods for firm i. The $INCR_{i,t} \times DECR_{i,t-1}$ dummy takes the value of 1 if sales revenue increases in current period (between $t-1$ and $t$) but decreases in previous period (between $t-2$ and $t-1$), and 0 otherwise. The $DECR_{i,t} \times INCR_{i,t-1}$ dummy takes the value of 1 when sales revenue decreases in current period and increases in previous period, and 0 otherwise. The $DECR_{i,t} \times DECR_{i,t-1}$ dummy variable takes the value of 1 if sales revenue decreases for two consecutive periods, and 0 otherwise. The base case reflected in the coefficient $\beta_1$ is when sales revenue increases in both prior and current periods.

We justify the use of the log-linear model based on three considerations. First, we used the Davidson and MacKinnon (1981) test to examine the appropriateness of a log-linear model compared to a linear model. The linear model was rejected in favor of the log-linear model. Second, cross-sectional and pooled estimation is likely to result in heteroscedasticity. The log-linear specification reduces the potential for heteroscedasticity in the estimation. Third, the use of a log-linear model facilitates an economic interpretation of the coefficients. In our model, for instance, the coefficient $\beta_1$ measures the percentage increase in SG&A costs with a one percent increase in sales revenue. As observed earlier, the base case is an increase in sales revenue for two consecutive periods when all dummies take the value of 0. Therefore, $\beta_1$ measures the percentage of variation in SG&A costs for a 1% variation in sales revenue in the Case-(I)}
$I_{t-1}$). The sum of coefficients $\beta_1 + \beta_2$, thus, measures the magnitude of increase in SG&A costs for a 1% increase in sales revenue in Case-$(I_t D_{t-1})$ and so on and so forth.

To facilitate easier interpretation of the coefficients from the model we construct four new parameters to represent the magnitude of change in SG&A costs per unit of change in sales revenue in each of our four cases. Thus, $\beta_{II} = \beta_1$ represents the magnitude of increase in SG&A costs when sales increase in both current and previous periods i.e. Case-$(I_t I_{t-1})$. Likewise $\beta_{ID} = \beta_1 + \beta_2$ represents Case-$(I_t D_{t-1})$, $\beta_{DI} = \beta_1 + \beta_3$ represents Case-$(D_t I_{t-1})$, and finally $\beta_{DD} = \beta_1 + \beta_4$ represents Case-$(D_t D_{t-1})$.

Hypothesis 1 predicts that the magnitude of increase in SG&A in Case-$(I_t I_{t-1})$ will be larger than the magnitude of increase in Case-$(D_t I_{t-1})$ i.e. $\beta_{II} > \beta_{DI}$. Hypothesis 2 predicts that the magnitude of decrease in SG&A in Case-$(D_t D_{t-1})$ will be larger than that the corresponding magnitude in Case-$(D_t I_{t-1})$ i.e. $\beta_{DD} > \beta_{ID}$. Finally, hypothesis 3 predicts $\beta_{II} > \beta_{ID}$ while hypothesis 4 predicts $\beta_{DD} > \beta_{DI}$.

4. Sample Statistics and Results

4.1 Sample Statistics

Following ABJ, we use SG&A costs (Compustat item number = 189) and sales revenue (Compustat item number = 12) in our analyses. We chose the same time interval 1979-1998 as in ABJ. However, our data are taken from the full coverage tapes of Compustat 2001 whereas their data utilize the 1999 Compustat tapes. Therefore, although we have used the same time interval, our sample is larger. We deleted observations with missing values for SG&A costs or sales revenue for current and

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3 Our results are very similar when we draw our sample for the time interval 1979-1998 from the Compustat 1999 tapes.
preceding years. We trim the data by deleting the extreme observations from the top 1% and bottom 1% of the data set. We also deleted the observations where SG&A costs are greater than sales revenue or SG&A costs are negative. The total number of firms remaining in the sample is 14,177 and the total number of firm-year observations is 98,896.

Descriptive statistics are shown in Table 1. The mean sales revenue is $1.033 billion (median = $81.63 million, standard deviation = $5,101.08 million) while the mean SG&A costs is $185.07 million (median = $16.13 million, standard deviation = $884.64 million). Panel A of Table 2 exhibits the frequency of the four cases described above and the sales change associated with each of them. As can be seen from the table, the sample is dominated (59.30%) by firm-year observations that belong to Case-(I, t-1). The remaining cases have frequencies ranging from 10.92% to 17.05%. Panel B of Table 2 shows the median percentage of increase (decrease) for sales revenue, SG&A costs and the difference between sales change and SG&A cost change for each of the four cases. Given an increase in year t-1, the numbers seem consistent with the results of ABJ i.e. SG&A costs relative to sales rise more when sales increase than they fall when sales decrease. Given a sales increase in year t-1, the median difference between the change in sales and change in SG&A costs for a sales increase in year t is only 1.28%, much less than the median difference of 9.06% when sales decrease. On the other hand, the numbers given a sales decrease in year t-1 do not seem consistent with ABJ. The median difference between the change in sales and change in SG&A costs for a sales increase in year t is 5.97% which is greater than the median difference of 4.86% when sales decrease. This is the opposite of the case when sales increase in year t-1.
4.2 Results of Cross-Sectional Pooled Estimation

The results for the pooled sample estimation of model A using OLS are provided in Table 3. The changes in SG&A costs are regressed on changes in sales revenue and dummy interaction terms representing the four cases. All the coefficients in model A are highly significant (p-values < 0.0001). As described in section 3.1, we report the combined coefficients that measure the total magnitude of change in SG&A cost per unit change in sales revenue for each case. The estimated combined coefficients are presented in panel A. We use F-tests to compare the unrestricted model with a restricted model where the restrictions are implied by each of our hypotheses 1 through 4. The results of these hypotheses tests are presented in panel B of table 3.

From panel A, $\hat{\beta}_{I} = 0.6582$ indicates that in Case-(I, I-1), the SG&A costs increase 0.66% for a 1% increase in sales revenue. $\hat{\beta}_{D1} = 0.3695$ implies that in Case-(D, I-I) SG&A costs decrease only 0.37% for a 1% decrease in sales revenue. This finding is similar to the ABJ results which show that costs do not decrease by as much as they increase in proportion to changes in sales revenue. The result from the F-test shows that the difference between $\hat{\beta}_{I}$ and $\hat{\beta}_{D1}$ is statistically significant (p-value < 0.0001). This supports our hypothesis 1 that given an increase in sales revenue in the previous period, the relative magnitude of an increase in SG&A costs for an increase in sales revenue in the current period is greater than the relative magnitude of a decrease in SG&A costs for a decrease in sales revenue in the current period.

The magnitude of stickiness in our model can be measured by the difference between $\hat{\beta}_{I}$ and $\hat{\beta}_{D1}$. The magnitude of stickiness in ABJ model is only 0.19 whereas in our model it is 0.29. Thus, by controlling for the prior period’s sales change, we see that
the stickiness effect is even stronger than that previously recorded by ABJ. This supports the importance of considering the sales change in both current as well as prior periods while examining cost behavior.

The estimate $\hat{\beta}_{DD} = 0.6125$ implies that SG&A costs decrease 0.61% for a one percent decrease in sales in Case-(D, $D_{t-1}$). However, $\hat{\beta}_{ID} = 0.2997$ shows that costs increase only 0.30% for a one percent increase in sales in Case-(I, $D_{t-1}$). The F-test shows that the difference between these two coefficients is statistically significant (p-value < 0.0001). This result is the opposite of the ABJ results. ABJ report that costs do not decrease by as much as they increase in proportion to changes in sales revenue. However, when we condition based on a decrease in prior period sales revenue, we find that costs decrease more than they increase. This result provides support for our hypothesis 2. The result underscores the importance of including the prior period’s sales change when evaluating cost behavior.

This result can be explained by the theoretical considerations that govern managers’ rational decision-making. While making decisions regarding capacity in the current period, managers will consider the surplus capacity inherited from the past as well as expectations of future demand conditions. The direction of sales changes in the prior period can affect both the inherited slack capacity and perceptions about demand trends. When sales revenue decreases in two consecutive periods, managers’ assessments about demand reversing in the next period will be lower. Additionally, there is likely to be more slack capacity available when there has been two consecutive periods of sales decreases. This explains why the change in SG&A costs will be larger in Case-(D, $D_{t-1}$) than in Case-(I, $D_{t-1}$).
This analysis raises an important question - how do we reconcile this result with that of ABJ? In our model there are two cases where costs increase in current period and two cases where costs decrease. When sales decrease in the current year, \( \hat{\beta}_I \) (which represents the magnitude of increase in SG&A costs when sales increase) in the ABJ model is the weighted average of \( \hat{\beta}_{II} \) and \( \hat{\beta}_{ID} \) in our model, where the weights are based on their respective frequencies of sample observations. Recall from table 2 that the frequency of Case-(I, D_{t-1}) is 59.31% while that of Case-(I, I_{t-1}) is 12.73%. This suggests that the ABJ results are largely driven by the observations in Case-(I, I_{t-1}) which dominate the sample.

The estimated coefficient of \( \hat{\beta}_{II} \) is greater than \( \hat{\beta}_{ID} \) and the difference is statistically significant (p-value <0.0001). This result shows that costs increase more when there are two consecutive periods of sales increase than when current period’s sales increase is preceded by a decrease in the previous period. This is consistent with our hypothesis 3 indicating that there is an asymmetric behavior of costs when there are upward adjustments to costs. This finding is interesting since in both Case-(I, I_{t-1}) and Case-(I, D_{t-1}), sales revenue increases in the current period. The difference between these two cases is the direction of sales change in the prior period. This result further underscores the importance of including the prior-period in such analyses. Finally, we find that \( \hat{\beta}_{DI} \) is greater than \( \hat{\beta}_{DD} \) which supports hypothesis 4. Again, while sales revenue decreases in the current period in both these cases, the only difference is the direction of sales change in the prior period.

To examine the effect of ignoring the interaction variables in our model, we regress the change in SG&A costs only on the change in sales revenue by dropping the
interaction variables for Case-(I_t D_{t-1}), Case-(D_t I_{t-1}) and Case-(D_t D_{t-1}) from Model A. The estimated coefficient $\hat{\beta}_1$ for this additional model is 0.5665 (p-value < 0.0001) which indicates the average variation in SG&A costs for a 1% variation in sales revenue if we do not take into consideration the effect of the direction of the preceding year’s sales change. The variation in SG&A costs for a 1% variation in sales revenue in this model is lower than the variation in Case-(I_t I_{t-1}) and Case-(D_t D_{t-1}) and higher than the variation in Case-(D_t I_{t-1}) and Case-(I_t D_{t-1}).

We examined the possibility that our results are influenced by heteroscedasticity. The White (1980) test rejected the presence of heteroscedasticity. Additionally we applied Belsley, Kuh and Welsch (1980) diagnostics to test for multicollinearity among the regressor terms in the model. The condition indices for the regressors are all less than 3 and the variance inflation factors are less than 2, indicating that multicollinearity is not a problem in our estimation (Neter et al. 1996).

4.3 Results of Time-series Model

In addition to the cross-sectional analysis carried out using a pooled estimation method, we employ a time-series model to examine cost-stickiness for individual firms across time. The model estimates separate parameters for individual firms. We include firms that have at least 10 observations and three or more decreases in sales revenue during the sample period. The firm-by-firm model consists of 2,736 firms (as compared to 14,177 in the cross-sectional pooled sample). We trim the top 1% and bottom 1% extreme observations and eliminate the firms with negative values of $\hat{\beta}_1$. The remaining number of firms is 2,356 and the number of firm-year observations is 36,639. We aggregate the $t$-statistics from the firm-by-firm regressions following Dechow, Huson
and Sloan (1994) and Lambert and Larcker (1987). Finally, we calculate the mean of the coefficient estimates from the firm-by-firm regressions.

The mean values of the firm-by-firm regression coefficients in Panel A of Table 4 are $\hat{\beta}_{II} = 0.7697$, $\hat{\beta}_{DI} = 0.3226$, $\hat{\beta}_{DD} = 0.7493$ and $\hat{\beta}_{ID} = 0.3739$. The F-test results in Panel B show that all of the coefficients are statistically different from each other (p-values < 0.0001). The results of the firm-by-firm regressions confirm all our findings from the cross-sectional pooled regression and provide support for the robustness of our results. The difference in the magnitude of increase in SG&A costs for a 1% increase in sales revenue between Case-(I, I, -1) and Case-(D, I, -1) is 0.4472, providing strong evidence in support of hypothesis 1. Likewise the difference in the magnitude of increase in SG&A costs for a unit increase in sales revenue between Case-(D, D, -1) and Case-(I, D, -1) is 0.3754, supporting hypothesis 2. As explained in section 4.2 this finding contradicts the ABJ result that the magnitude of changes in SG&A costs is greater when costs increase than when costs decrease. These results further indicate the importance of understanding the effect of prior period sales changes on sticky cost behavior.

The firm by firm regression results also support hypothesis 3 indicating that costs increase more in Case-(I, I, -1) than in Case-(I, D, -1) consistent with asymmetry in upward adjustment to costs. Similarly, hypothesis 4 is also supported by the results in Table 4 indicating that costs decrease more in Case-(D, D, -1) than in Case-(D, I, -1) consistent with the asymmetry in downward adjustments to costs.

The aggregate $Z$-statistics used in these tests require the maintained assumption of cross-sectional independence. To check for cross-sectional independence,
we randomly selected 100 firms, each with 20 firm-year observations, and estimated pairwise correlations between the regression residuals. The mean correlation is 0.035, suggesting that our data do not violate the cross-sectional independence assumption.

4.4. Extension to Additional Periods

So far we have argued that it is important to consider the history of changes in activity while predicting cost behavior in the current period. We extended the ABJ framework to include the effects of prior period changes, arguing that surplus capacity inherited from the prior period affects the decisions of managers who are making capacity decisions. We found that the inclusion of the prior period sales changes reverses the findings of ABJ when we condition the results based on a sales decline in the prior period. An obvious question that arises next is whether looking back one period further into the history of changes in activity adds any useful information in predicting current period cost behavior. To examine this question, we develop and test a model that includes two prior periods of sales and cost behavior.

Under this representation, we have 8 different cases based on the direction of sales change in each of the three periods considered. To facilitate the interpretation of the results, we divide these cases into three groups as in figure 3 with notation similar to that used in previous sections.

In the two cases under Group 1, the direction of sales change is the same in each of the three periods. As in our two-period model, the trend of sales changes in the same direction in every year provides greater confidence to managers of a low probability of demand reversal. This implies that we are likely to see a larger magnitude of cost changes in the same direction as sales. In Group 2, the direction of sales change is the same in
periods t and t-1, but opposite in period t-2. Thus, the magnitude of sales change is likely to be smaller in these two cases than in the corresponding cases in Group 1. Group 3 consists of cases in which the direction of sales change in period t is the reverse of period t-1. This will make managers less sure of the continuance of any trend in sales, making them less likely to make changes in costs during period t. Thus, we expect to see the lowest magnitude of cost changes for Group 3.

Accordingly, and consistent with hypothesis 1, we expect that the magnitude of change in costs in Case-(I_t,I_{t-1}I_{t-2}) will be higher than in Cases (D_tI_{t-1}I_{t-2}) and (D_tD_{t-1}I_{t-2}). Also, the magnitude of changes in costs in Case-(D_tD_{t-1}D_{t-2}) will be higher than in Cases (I_tD_{t-1}D_{t-2}) and (I_tD_{t-1}D_{t-2}) which is consistent with hypothesis 2. Hypothesis 3 suggests that the magnitude of change in costs will be higher in Case-(I_tD_{t-1}D_{t-2}) than in Cases (I_tD_tD_{t-2}) and (I_tD_tD_{t-2}). Finally, consistent with hypothesis 4 we expect to find the magnitude of cost changes to be higher in Case-(D_tD_tD_{t-2}) than in Cases (D_tD_tD_{t-2}) and (D_tD_tD_{t-2}).

To examine all these propositions, we design an empirical model as follows:

Model B

$$
\log \left[ \frac{SG \& A_i,t}{SG \& A_{i,t-1}} \right] = \beta_0 + \beta_1 \log \left[ \frac{Revenue_{i,t}}{Revenue_{i,t-1}} \right] + \beta_2 \log \left[ \frac{Revenue_{i,t}}{Revenue_{i,t-1}} \right] + \\
\beta_3 \log \left[ \frac{Revenue_{i,t}}{Revenue_{i,t-1}} \right] + \beta_4 \log \left[ \frac{Revenue_{i,t}}{Revenue_{i,t-1}} \right] + \beta_5 \log \left[ \frac{Revenue_{i,t}}{Revenue_{i,t-1}} \right] + \\
\beta_6 \log \left[ \frac{Revenue_{i,t}}{Revenue_{i,t-1}} \right] + \beta_7 \log \left[ \frac{Revenue_{i,t}}{Revenue_{i,t-1}} \right] + \beta_8 \log \left[ \frac{Revenue_{i,t}}{Revenue_{i,t-1}} \right] + \epsilon_t
$$

where DDD is a dummy variable that is equal to 1 when sales decrease in years t, t-1 and t-2, and 0 otherwise; DDI is a dummy variables that takes the value 1 when sales
decrease in years t and t-1, but increase in year t-2; and so on and so forth. The base case for this model is III.

The results from the estimation of model 3 are presented in Table 5. We carry out one-sided tests to compare the magnitude of the coefficients across groups. As expected, the cases in Group 1 have the largest coefficients, followed by Group 2 and then Group 3. We also carry out tests to see if the results are consistent with hypotheses 1 to 4 which were examined using our two-period model. All the findings from our three-period model are consistent with our hypotheses in Section 2.

4.5 Components of Costs

In Model A, we examined the cost behavior of selling, general and administrative costs. We do know, however, that SG&A costs consist of several different cost types: advertising costs, research and development costs, marketing costs, and administrative costs. It is possible, that the behavior we observe could be driven by one of these cost types, and hence may not be representative of the behavior of individual cost components. Thus, to examine whether similar cost behavior is observed across different cost types, including cost of goods sold, we analyze Model A separately for different cost components for which data can be obtained from Compustat.

Model C:

\[
\log \left( \frac{\text{Costs}_{ij}}{\text{Costs}_{i,j-1}} \right) = \beta_0 + \beta_1 \log \left( \frac{\text{REV}_{ij}}{\text{REV}_{i,j-1}} \right) + \beta_2 \cdot \text{INCR}_{i,j} \cdot \text{DECR}_{i,j-1} \cdot \log \left( \frac{\text{REV}_{ij}}{\text{REV}_{i,j-1}} \right) + \\
\beta_3 \cdot \text{DECR}_{i,j} \cdot \text{INCR}_{i,j-1} \cdot \log \left( \frac{\text{REV}_{ij}}{\text{REV}_{i,j-1}} \right) + \beta_4 \cdot \text{DECR}_{i,j} \cdot \text{DECR}_{i,j-1} \cdot \log \left( \frac{\text{REV}_{ij}}{\text{REV}_{i,j-1}} \right) + \epsilon_{ij}
\]

Specifically, we replace SG&A costs as a dependent variable with the following cost components: Advertising costs, Research and Development costs, Other SG&A costs,
and Cost of Goods Sold. The results obtained from estimating Model C are provided in Panel A of Table 6. The results show that the cost behavior observed is similar across different cost components. In Panel B, we summarize the coefficients representing each of our four cases. For each of the costs we find evidence to confirm all four of our hypotheses: i.e. for each cost, we find $\beta_{II} > \beta_{DI}$ (Hypothesis 1), $\beta_{DD} > \beta_{ID}$ (Hypothesis 2), $\beta_{II} > \beta_{ID}$ (Hypothesis 3), and $\beta_{DD} > \beta_{DI}$ (Hypothesis 4). This confirms that results form estimating Model A are not driven by any one particular SG&A cost component, and that the cost behavior observed by combining all SG&A costs is representative of the behavior of individual cost components, including cost of goods sold.

5. Conclusion

The understanding of cost behavior is fundamental to management accounting. The traditional idea of cost behavior has been that costs can be treated as fixed or variable based on their relationship to volume or a related cost driver. ABJ argued that it is also important to consider the direction of sales change. In their analyses of cost behavior, ABJ argue and demonstrate that there is asymmetric cost behavior for periods when sales increased compared to periods when sales decreased. They show that in proportion to changes in sales, costs increase more in periods of sales increases than they fall in periods of sales decreases. They termed this as the ‘sticky behavior’ of costs. In this paper we have argued that it is not sufficient to consider only the direction of sales change in the current period. It is important to also consider the direction of sales changes in the prior-period while examining cost behavior. If the availability of surplus capacity from the past and confidence about likelihood of reversal in direction of sales change are ignored
in analyses of cost behavior, then the results and conclusions drawn from such analyses can be misleading.

In our first set of hypotheses we examined the ABJ results to show that while the results hold in one case, they do not hold in another case. The ABJ results hold when we consider cost changes in the current period given a sales increase in the prior period (our hypothesis 1). But, given a sales decrease in the prior period, the results of ABJ are reversed i.e. in proportion to changes in sales revenue, costs fall more in periods of sales decreases than they increase in periods of sales increases (our hypothesis 2). In our second set of hypotheses, we explicitly considered the effect of the direction of prior period sales changes on the magnitude of cost changes in the current period. We found that consecutive sales changes in the same direction increase the magnitude of cost changes. Hence, when sales increase in both the current and prior periods, the current period cost changes are higher than when sales decreased in the prior period and subsequently increased in the current period (our hypothesis 3). Also, when sales decrease in two consecutive periods, the magnitude of cost decrease is higher than when sales increased in the prior period and subsequently decreased in the current period (our hypothesis 4).

This research provides an important step in the development of a theory of cost behavior predicated on cost changes resulting from managerial choices. On the one hand, managers must evaluate the probability of demand reversal in the future before making decisions on changes to capacity. On the other hand, rational managers will balance this consideration with the surplus capacity that is inherited from the prior period. Empirical evidence strongly supports the theoretical predictions. Given a sales increase in the
current period, costs increase (decrease) more when there was a sales increase (decrease) in the prior period than when there was a sales decrease (increase). This underscores the fact that sales changes in the prior period affect resource capacity decisions of managers and hence must be included in the analysis of cost behavior. This alternative model of cost behavior predicated on rational managerial decision making provides a better understanding of the true behavior of costs, than the traditional model which simply links the behavior of costs to changes in volume without considering the important intermediary role of managers who must decide whether to augment or diminish resource capacity and hence increase or decrease costs.
REFERENCES


FIGURE 1
Four Scenarios of Direction of Sales Changes in Two Consecutive Years

<table>
<thead>
<tr>
<th>In the Prior Period</th>
<th>Sales Increase</th>
<th>Sales Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sales Increase</strong></td>
<td>Case-(I_t, I_{t-1})</td>
<td>Case-(D_t, I_{t-1})</td>
</tr>
<tr>
<td><strong>Sales Decrease</strong></td>
<td>Case-(I_t, D_{t-1})</td>
<td>Case-(D_t, D_{t-1})</td>
</tr>
</tbody>
</table>
FIGURE 2
Comparison of Relative Magnitudes of Changes in SG&A Costs

Case-(I_tI_{t-1}) \quad \text{Is greater than} \quad \text{Case-(D_tI_{t-1})}

\text{H1:}

Is greater than

Case-(I_tD_{t-1}) \quad \text{Is greater than} \quad \text{Case-(D_tD_{t-1})}

\text{H2:}

Case-(D_tD_{t-1}) \quad \text{Is less than}

\text{H3:}

Is greater than

\text{H4:}

Is less than
FIGURE 3
Groups Based on Consistency in Direction of Sales Change over Time

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong Consistency</td>
<td>Recent Consistency</td>
<td>Recent Inconsistency</td>
</tr>
<tr>
<td>Case-(D_tD_t-1D_t-2)</td>
<td>Case-(D_tD_t-1I_t-2)</td>
<td>Case-(D_tI_t-1D_t-2)</td>
</tr>
<tr>
<td>Case-(I_tI_t-1I_t-2)</td>
<td>Case-(I_tI_t-1D_t-2)</td>
<td>Case-(D_tI_t-1I_t-2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Case-(I_tD_t-1D_t-2)</td>
</tr>
</tbody>
</table>

28
TABLE 1
Descriptive Statistics for Sales Revenue and SG&A Costs

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Median</th>
<th>Lower Quartile</th>
<th>Upper Quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales revenue</td>
<td>$1,032.90</td>
<td>$5,101.08</td>
<td>$81.63</td>
<td>$18.82</td>
<td>$384.44</td>
</tr>
<tr>
<td>Selling, general and administrative (SG&amp;A) costs</td>
<td>$185.07</td>
<td>$884.64</td>
<td>$16.13</td>
<td>$4.29</td>
<td>$68.37</td>
</tr>
<tr>
<td>SG&amp;A costs as a percentage of revenue</td>
<td>26.41%</td>
<td>17.63%</td>
<td>22.51%</td>
<td>13.92%</td>
<td>34.17%</td>
</tr>
<tr>
<td>SG&amp;A costs as a percentage of operating costs</td>
<td>29.58%</td>
<td>17.91%</td>
<td>26.16%</td>
<td>16.32%</td>
<td>39.64%</td>
</tr>
</tbody>
</table>

Notes:
Our data are from Compustat annual files for the period 1979 to 1998. We trimmed off the top and bottom 1% of the sample. After deleting extreme observations, our sample contains 98,896 firm-year observations for 14,177 firms. Additionally the observations missing sales revenue (Compustat item number = 12) or SG&A costs (Compustat item number = 189) in current or preceding year are deleted. The observations with SG&A costs exceeding sales revenue are also deleted from the sample. All numbers are in millions of dollars (except percentages). Operating costs are the sum of SG&A costs and Cost of Goods Sold (Compustat item number = 41).
TABLE 2
Summary Statistics

PANEL A: Percentage of firm-years in sample

<table>
<thead>
<tr>
<th>Year t-1</th>
<th>INCR</th>
<th>DECR</th>
<th>Marginal Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCR</td>
<td>59.30%</td>
<td>17.05%</td>
<td>76.35%</td>
</tr>
<tr>
<td>DECR</td>
<td>12.73%</td>
<td>10.92%</td>
<td>23.65%</td>
</tr>
<tr>
<td>Marginal Total</td>
<td>72.03%</td>
<td>27.97%</td>
<td>100%</td>
</tr>
</tbody>
</table>

PANEL B: Median percentage increases (decreases) in sales revenue, SG&A costs and difference between sales change and SG&A cost change.

<table>
<thead>
<tr>
<th>Year t-1</th>
<th>INCR</th>
<th>DECR</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCR</td>
<td>17.97%</td>
<td>(9.32)%</td>
</tr>
<tr>
<td></td>
<td>16.69%</td>
<td>(0.26)%</td>
</tr>
<tr>
<td></td>
<td>1.28%</td>
<td>(9.06)%</td>
</tr>
<tr>
<td>DECR</td>
<td>13.03%</td>
<td>(12.09)%</td>
</tr>
<tr>
<td></td>
<td>7.06%</td>
<td>(7.23)%</td>
</tr>
<tr>
<td></td>
<td>5.97%</td>
<td>(4.86)%</td>
</tr>
</tbody>
</table>
TABLE 3
Results of Pooled Cross-sectional Estimation Examining the Relationship between Annual Changes in SG&A Costs and Annual Changes in Sales Revenue

Model A:
\[
\log \left[ \frac{SG & A, t}{SG & A, t-1} \right] = \beta_0 + \beta_1 \log \left[ \frac{REV, t}{REV, t-1} \right] + \beta_2 \text{INCR, } t-1 * \log \left[ \frac{REV, t}{REV, t-1} \right] + \\
\beta_3 \text{DECR, } t-1 * \log \left[ \frac{REV, t}{REV, t-1} \right] + \beta_4 \text{DECR, } t-1 * \log \left[ \frac{REV, t}{REV, t-1} \right] + \epsilon_{i,t}
\]

PANEL A: Results of pooled cross-sectional estimation of Model A

<table>
<thead>
<tr>
<th>Predicted</th>
<th>Parameter</th>
<th>t-statistic</th>
<th>p-value (one-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\hat{\beta}_1)</td>
<td>+</td>
<td>0.6582</td>
<td>224.11</td>
</tr>
<tr>
<td>(\hat{\beta}_2)</td>
<td>-</td>
<td>-0.3585</td>
<td>-59.39</td>
</tr>
<tr>
<td>(\hat{\beta}_3)</td>
<td>-</td>
<td>-0.2887</td>
<td>-38.39</td>
</tr>
<tr>
<td>(\hat{\beta}_4)</td>
<td>-</td>
<td>-0.0457</td>
<td>-5.74</td>
</tr>
</tbody>
</table>

Adjusted \(R^2\): 0.4398

PANEL B: Summary of coefficient estimates and hypothesis tests:

<table>
<thead>
<tr>
<th>Year t</th>
<th>INCR</th>
<th>DECR</th>
<th>Marginal Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INCR</strong></td>
<td>(\hat{\beta}_{II}) = 0.6582</td>
<td>(\hat{\beta}_{DI}) = 0.3695</td>
<td>(\hat{\beta}_{.t}) = 0.5945</td>
</tr>
<tr>
<td><strong>DECR</strong></td>
<td>(\hat{\beta}_{ID}) = 0.2997</td>
<td>(\hat{\beta}_{DD}) = 0.6125</td>
<td>(\hat{\beta}_{.D}) = 0.4440</td>
</tr>
<tr>
<td><strong>Marginal Total</strong></td>
<td>(\hat{\beta}_{..}) = 0.5948</td>
<td>(\hat{\beta}_{..}) = 0.4652</td>
<td>(\hat{\beta}_{..}) = 0.5572</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesis 1: (\hat{\beta}<em>{II} &gt; \hat{\beta}</em>{DI}) [i.e. (\hat{\beta}_1 &gt; (\hat{\beta}_1 + \hat{\beta}_3))]</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hypothesis 2: (\hat{\beta}<em>{DD} &gt; \hat{\beta}</em>{ID}) [i.e. ((\hat{\beta}_1 + \hat{\beta}_4) &gt; (\hat{\beta}_1 + \hat{\beta}_2))]</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hypothesis 3: (\hat{\beta}<em>{II} &gt; \hat{\beta}</em>{ID}) [i.e. (\hat{\beta}_1 &gt; (\hat{\beta}_1 + \hat{\beta}_2))]</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hypothesis 4: (\hat{\beta}<em>{DD} &gt; \hat{\beta}</em>{DI}) [i.e. ((\hat{\beta}_1 + \hat{\beta}_4) &gt; (\hat{\beta}_1 + \hat{\beta}_3))]</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>ABJ</td>
<td>(\hat{\beta}<em>{..} &gt; \hat{\beta}</em>{..}) [i.e. ((\hat{\beta}_1 + \hat{\beta}_2) &gt; (\hat{\beta}_1 + \hat{\beta}_3 + \hat{\beta}_4))]</td>
</tr>
</tbody>
</table>
**Variable Definitions:**

REV is sales revenue (Compustat data12).

SG&A is sales and general administrative expenses (Compustat data189).

\( (INCR_{i,t-1,DECR_{i,t-1}}) \) takes value of 1 when sales revenue of firm \( i \) increases in current year (between \( t \) and \( t-1 \)) having decreased in previous year (between period \( t-1 \) and \( t-2 \)) (Corresponds to case-(I, D_{t-1})).

\( (DECR_{i,t-1,INCR_{i,t-1}}) \) takes value of 1 when sales revenue of firm \( i \) decreases in current year and increases in previous year (Corresponds to case-(D, I_{t-1})).

\( (DECR_{i,t,DECR_{i,t-1}}) \) takes value of 1 when sales revenue of firm \( i \) decreases in both current and previous years. (Corresponds to case-(D, D_{t-1})).

**Coefficient Definitions:**

\( \hat{\beta}_{II} = \) Percentage increase in SG&A costs per unit increase in sales when sales revenue increases in both current and previous periods. \( \hat{\beta}_{II} = \hat{\beta}_1 \) in model A.

\( \hat{\beta}_{DI} = \) Percentage decrease in SG&A costs per unit decrease in sales when sales revenue decreases in the current period having increased in the previous period. \( \hat{\beta}_{DI} = \hat{\beta}_1 + \hat{\beta}_3 \) in model A.\( \hat{\beta}_{ID} = \) Percentage increase in SG&A costs per unit increase in sales when sales revenue increases in the current period having decreased in the previous period. \( \hat{\beta}_{ID} = \hat{\beta}_1 + \hat{\beta}_2 \) in model A.

\( \hat{\beta}_{DD} = \) Percentage decrease in SG&A costs per unit decrease in sales when sales revenue decreases in both current and previous periods. \( \hat{\beta}_{DD} = \hat{\beta}_1 + \hat{\beta}_4 \) in model A.

\( \hat{\beta}_{II} = \) Percentage increase in SG&A costs per unit increase in sales when sales revenue increases in the current period. \[ \hat{\beta}_{II} = \{(frequency_{II} \times \hat{\beta}_{II}) + (frequency_{ID} \times \hat{\beta}_{ID})\} \]

\( \hat{\beta}_{DD} = \) Percentage decrease in SG&A costs per unit increase in sales when sales revenue decreases in the current period. \[ \hat{\beta}_{DD} = \{(frequency_{DI} \times \hat{\beta}_{DI}) + (frequency_{DD} \times \hat{\beta}_{DD})\} \]

\( \hat{\beta}_{ID} = \) Percentage change in SG&A costs per unit increase in sales when sales revenue increases in the previous period. \[ \hat{\beta}_{ID} = \{(frequency_{II} \times \hat{\beta}_{II}) + (frequency_{DI} \times \hat{\beta}_{DI})\} \]

\( \hat{\beta}_{DD} = \) Percentage change in SG&A costs per unit increase in sales when sales revenue decreases in the previous period. \[ \hat{\beta}_{DD} = \{(frequency_{ID} \times \hat{\beta}_{ID}) + (frequency_{DD} \times \hat{\beta}_{DD})\} \]

**Notes:**

1- Panel B reports the values of \( \hat{\beta}_{II}, \hat{\beta}_{DI}, \hat{\beta}_{DD} \), and \( \hat{\beta}_{ID} \) generated from pooled cross-sectional estimation of model A reported in Panel A.

2- The p-values reported in Panel B are tests of the null hypothesis of equality of coefficients, carried out by constraining the coefficients to be equal.

3- Marginal Total row or column in Panel B shows the weighted average of change in costs for that row or column. For example for a column, it is calculated as relative frequency of a cell in that column times the magnitude of change in that cell. The relative frequencies are from Panel A of Table 2.
TABLE 4
Results of Firm-by-Firm Regressions Examining the Relationship between Annual Changes in SG&A Costs and Annual Changes in Sales Revenue

Model A:

\[ \log \left( \frac{SG \& A_{i,t}}{SG \& A_{i,t-1}} \right) = \beta_0 + \beta_1 \log \left( \frac{REV_{i,t}}{REV_{i,t-1}} \right) + \beta_2 \text{INCR}_{i,t} \cdot \text{DECR}_{i,t-1} \cdot \log \left( \frac{REV_{i,t}}{REV_{i,t-1}} \right) + \beta_3 \text{DECR}_{i,t} \cdot \text{INCR}_{i,t-1} \cdot \log \left( \frac{REV_{i,t}}{REV_{i,t-1}} \right) + \epsilon_{i,t} \]

PANEL A: Results of firm-by-firm estimation of Model A

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Predicted Sign</th>
<th>Mean of the Estimated Parameters</th>
<th>Median of the Estimated Parameters</th>
<th>Standard Error of the Estimated Parameters</th>
<th>Aggregated Z-statistics</th>
<th>p-value (one-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \hat{\beta}_1 )</td>
<td>+</td>
<td>0.7703</td>
<td>0.7483</td>
<td>0.4027</td>
<td>139.17</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>( \hat{\beta}_2 )</td>
<td>-</td>
<td>-0.3950</td>
<td>-0.2824</td>
<td>1.0423</td>
<td>-25.48</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>( \hat{\beta}_3 )</td>
<td>-</td>
<td>-0.4472</td>
<td>-0.3495</td>
<td>1.2865</td>
<td>-20.94</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>( \hat{\beta}_4 )</td>
<td>-</td>
<td>-0.0211</td>
<td>0</td>
<td>1.7385</td>
<td>-4.16</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

PANEL B: Summary of coefficient estimates and hypothesis tests:

<table>
<thead>
<tr>
<th>Year t</th>
<th>INCR</th>
<th>DECR</th>
<th>Marginal Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year t-1</td>
<td>( \hat{\beta}_{II} = 0.7697 )</td>
<td>( \hat{\beta}_{DI} = 0.3226 )</td>
<td>( \hat{\beta}_{L} = 0.6711 )</td>
</tr>
<tr>
<td>( \hat{\beta}_{ID} = 0.3739 )</td>
<td>( \hat{\beta}_{DD} = 0.7493 )</td>
<td>( \hat{\beta}_{D} = 0.5564 )</td>
<td></td>
</tr>
<tr>
<td>( \hat{\beta}_{..} = 0.6997 )</td>
<td>( \hat{\beta}_{..} = 0.4907 )</td>
<td>( \hat{\beta}_{..} = 0.6399 )</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test</th>
<th>p-value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesis 1: ( \hat{\beta}<em>{II} &gt; \hat{\beta}</em>{DI} ) \ [( \hat{\beta}_{L} &gt; (\hat{\beta}_1 + \hat{\beta}_3) )]</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Hypothesis 2: ( \hat{\beta}<em>{DD} &gt; \hat{\beta}</em>{ID} ) \ [( (\hat{\beta}_1 + \hat{\beta}_4) &gt; (\hat{\beta}_1 + \hat{\beta}_2) )]</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Hypothesis 3: ( \hat{\beta}<em>{II} &gt; \hat{\beta}</em>{ID} ) \ [( \hat{\beta}_L &gt; (\hat{\beta}_1 + \hat{\beta}_3) )]</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Hypothesis 4: ( \hat{\beta}<em>{DD} &gt; \hat{\beta}</em>{DI} ) \ [( (\hat{\beta}_1 + \hat{\beta}_4) &gt; (\hat{\beta}_1 + \hat{\beta}_3) )]</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>ABJ \ : ( \hat{\beta}_{L} &gt; (\hat{\beta}_1 + \hat{\beta}_4) ) \ [( (\hat{\beta}_1 + \hat{\beta}_3) &gt; (\hat{\beta}_1 + \hat{\beta}_3 + \hat{\beta}_4) )]</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

33
Variable Definitions:
REV is sales revenue (Compustat data12).
SG&A is sales and general administrative expenses (Compustat data189)

\( (INCR_{i,t} - DECR_{i,t-1}) \) takes value of 1 when sales revenue of firm \( i \) increases in current year (between \( t \) and \( t-1 \)) having decreased in previous year (between period \( t-1 \) and \( t-2 \)) (Corresponds to case-(I, D_i,t))

\( (DECR_{i,t} - INCR_{i,t-1}) \) takes value of 1 when sales revenue of firm \( i \) decreases in current year and increases in previous year (Corresponds to case-(D, I_i,t))

\( (DECR_{i,t} - DECR_{i,t-1}) \) takes value of 1 when sales revenue of firm \( i \) decreases in both current and previous years. (Corresponds to case-(D, D_i,t))

Coefficient Definitions:
\( \hat{\beta}_{II} = \text{Percentage increase in SG&A costs per unit increase in sales when sales revenue increases in both current and previous periods.} \)
\( \hat{\beta}_{II} = \hat{\beta}_1 \) in model A

\( \hat{\beta}_{DI} = \text{Percentage decrease in SG&A costs per unit decrease in sales when sales revenue decreases in the current period having increased in the previous period.} \)
\( \hat{\beta}_{DI} = \hat{\beta}_1 + \hat{\beta}_3 \) in model A

\( \hat{\beta}_{ID} = \text{Percentage increase in SG&A costs per unit increase in sales when sales revenue increases in the current period having decreased in the previous period.} \)
\( \hat{\beta}_{ID} = \hat{\beta}_1 + \hat{\beta}_2 \) in model A

\( \hat{\beta}_{DD} = \text{Percentage decrease in SG&A costs per unit decrease in sales when sales revenue decreases in both current and previous periods.} \)
\( \hat{\beta}_{DD} = \hat{\beta}_1 + \hat{\beta}_4 \) in model A

\( \hat{\beta}_{I*} = \text{Percentage increase in SG&A costs per unit increase in sales when sales revenue increases in the current period} \)
\( \hat{\beta}_{I*} = (\text{frequency}_{II} * \hat{\beta}_{II}) + (\text{frequency}_{ID} * \hat{\beta}_{ID}) \)

\( \hat{\beta}_{D*} = \text{Percentage decrease in SG&A costs per unit decrease in sales when sales revenue decreases in the current period} \)
\( \hat{\beta}_{D*} = (\text{frequency}_{DI} * \hat{\beta}_{DI}) + (\text{frequency}_{DD} * \hat{\beta}_{DD}) \)

\( \hat{\beta}_{I*} = \text{Percentage change in SG&A costs per unit increase in sales when sales revenue increases in the previous period} \)
\( \hat{\beta}_{I*} = (\text{frequency}_{II} * \hat{\beta}_{II}) + (\text{frequency}_{DI} * \hat{\beta}_{DI}) \)

\( \hat{\beta}_{D*} = \text{Percentage change in SG&A costs per unit increase in sales when sales revenue decreases in the previous period} \)
\( \hat{\beta}_{D*} = (\text{frequency}_{ID} * \hat{\beta}_{ID}) + (\text{frequency}_{DD} * \hat{\beta}_{DD}) \)

Notes:
1- Panel B reports the mean values of \( \hat{\beta}_{II} , \hat{\beta}_{DI} , \hat{\beta}_{DD} \) and \( \hat{\beta}_{ID} \) generated from firm-by-firm estimation of model A reported in Panel A.

2- The p-values reported in Panel B are tests of the null hypothesis of equality of coefficients, carried out by constraining the coefficients to be equal.

3- Marginal Total row or column in Panel B shows the weighted average of change in costs for that row or column. For example for a column, it is calculated as relative frequency of a cell in that column times the magnitude of change in that cell. The relative frequencies are from Panel A of Table 2.
Table 5

Results of Estimation of Three-Period Model

Model B

\[
\log \left( \frac{SG & A_{t_{i}}}{SG & A_{t_{i-1}}} \right) = \beta_0 + \beta_1 \log \left( \frac{Revenue_{t_i}}{Revenue_{t_{i-1}}} \right) + \beta_2 \times DDD \times \log \left( \frac{Revenue_{t_i}}{Revenue_{t_{i-1}}} \right) + \\
\beta_3 \times DDI \times \log \left( \frac{Revenue_{t_i}}{Revenue_{t_{i-1}}} \right) + \beta_4 \times DII \times \log \left( \frac{Revenue_{t_i}}{Revenue_{t_{i-1}}} \right) + \beta_5 \times IID \times \log \left( \frac{Revenue_{t_i}}{Revenue_{t_{i-1}}} \right) + \\
\beta_6 \times IDD \times \log \left( \frac{Revenue_{t_i}}{Revenue_{t_{i-1}}} \right) + \beta_7 \times IDI \times \log \left( \frac{Revenue_{t_i}}{Revenue_{t_{i-1}}} \right) + \beta_8 \times DID \times \log \left( \frac{Revenue_{t_i}}{Revenue_{t_{i-1}}} \right) + \epsilon_t
\]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Predicted Sign</th>
<th>Parameter Estimate</th>
<th>t-stat</th>
<th>p-value (one-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\hat{\beta}_1)</td>
<td>+</td>
<td>0.7231</td>
<td>194.45</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>(\hat{\beta}_2)</td>
<td>-</td>
<td>-0.0639</td>
<td>-5.59</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>(\hat{\beta}_3)</td>
<td>-</td>
<td>-0.1490</td>
<td>-14.83</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>(\hat{\beta}_4)</td>
<td>-</td>
<td>-0.3568</td>
<td>-38.34</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>(\hat{\beta}_5)</td>
<td>-</td>
<td>-0.1610</td>
<td>-34.12</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>(\hat{\beta}_6)</td>
<td>-</td>
<td>-0.4644</td>
<td>-45.92</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>(\hat{\beta}_7)</td>
<td>-</td>
<td>-0.3593</td>
<td>-44.57</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>(\hat{\beta}_8)</td>
<td>-</td>
<td>-0.3552</td>
<td>-32.72</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Adjusted-\(R^2\): 0.4413

Note: The comparisons of all \(\hat{\beta}\) s with each other are significant at \(p < 0.0001\), except for the comparisons of \(\hat{\beta}_3 = \hat{\beta}_5\), \(\hat{\beta}_4 = \hat{\beta}_7\), \(\hat{\beta}_4 = \hat{\beta}_8\) and \(\hat{\beta}_7 = \hat{\beta}_8\).

Coefficients Listed in Order of their Magnitude:

<table>
<thead>
<tr>
<th>Case</th>
<th>Coefficients</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\hat{\beta}_{III})</td>
<td>(\hat{\beta}_1)</td>
<td>0.7231</td>
</tr>
<tr>
<td>(\hat{\beta}_{DDD})</td>
<td>(\hat{\beta}_1 + \hat{\beta}_2)</td>
<td>0.6592</td>
</tr>
<tr>
<td>(\hat{\beta}_{DDI})</td>
<td>(\hat{\beta}_1 + \hat{\beta}_3)</td>
<td>0.5741</td>
</tr>
<tr>
<td>(\hat{\beta}_{IID})</td>
<td>(\hat{\beta}_1 + \hat{\beta}_5)</td>
<td>0.5621</td>
</tr>
<tr>
<td>(\hat{\beta}_{DID})</td>
<td>(\hat{\beta}_1 + \hat{\beta}_8)</td>
<td>0.3679</td>
</tr>
<tr>
<td>(\hat{\beta}_{DII})</td>
<td>(\hat{\beta}_1 + \hat{\beta}_4)</td>
<td>0.3663</td>
</tr>
<tr>
<td>(\hat{\beta}_{IDI})</td>
<td>(\hat{\beta}_1 + \hat{\beta}_7)</td>
<td>0.3638</td>
</tr>
<tr>
<td>(\hat{\beta}_{IDD})</td>
<td>(\hat{\beta}_1 + \hat{\beta}_6)</td>
<td>0.2587</td>
</tr>
</tbody>
</table>
Variable Definitions:

REV is sales revenue (Compustat data12).
SG&A is sales and general administrative expenses (Compustat data189)

DDD takes value of 1 when sales revenue of firm i decreases in years t, t-1, and t-2.
DDI takes value of 1 when sales revenue of firm i decreases in years t, t-1, but increases in t-2.
DIH takes value of 1 when sales revenue of firm i decreases in years t, but increases in t-1 and t-2.
IID takes value of 1 when sales revenue of firm i increases in years t, and t-1, but decreases in t-2.
IDD takes value of 1 when sales revenue of firm i increases in years t, but decreases in t-1 and t-2.
IDI takes value of 1 when sales revenue of firm i increases in years t, decreases in t-1 and increases in t-2.
DID takes value of 1 when sales revenue of firm i decreases in years t, increases in t-1 and decreases in t-2.

Notes:

1- Panel B reports the mean values of $\hat{\beta}_{III}$, $\hat{\beta}_{DDD}$, $\hat{\beta}_{DDI}$, $\hat{\beta}_{IID}$, $\hat{\beta}_{DID}$, $\hat{\beta}_{DIH}$, $\hat{\beta}_{IDD}$, $\hat{\beta}_{IDD}$ are generated from pooled estimation of model B reported in Panel A.
TABLE 6
Results of Pooled Cross-sectional Estimation Examining the Relationship between
Annual Changes in Different Cost Components and Annual Changes in Sales Revenue

Model C:

\[
\log \left( \frac{\text{Costs}_{i,t}}{\text{Costs}_{i,t-1}} \right) = \beta_0 + \beta_1 \log \left( \frac{\text{REV}_{i,t}}{\text{REV}_{i,t-1}} \right) + \beta_2 \times \text{INCR}_{i,t} \times \text{DECR}_{i,t-1} \times \log \left( \frac{\text{REV}_{i,t}}{\text{REV}_{i,t-1}} \right) + \\
\beta_3 \times \text{DECR}_{i,t} \times \text{INCR}_{i,t-1} \times \log \left( \frac{\text{REV}_{i,t}}{\text{REV}_{i,t-1}} \right) + \beta_4 \times \text{DECR}_{i,t} \times \text{DECR}_{i,t-1} \times \log \left( \frac{\text{REV}_{i,t}}{\text{REV}_{i,t-1}} \right) + \epsilon_{i,t}
\]

PANEL A: Results of pooled cross-sectional estimation

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Predicted Sign</th>
<th>R&amp;D Costs</th>
<th>Advertising Costs</th>
<th>Other SG&amp;A Costs</th>
<th>Cost of Goods Sold</th>
<th>Total SG&amp;A Costs (Model A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \hat{\beta}_1 )</td>
<td>+</td>
<td>0.5266***</td>
<td>0.6799***</td>
<td>0.6648***</td>
<td>0.9721***</td>
<td>0.6582***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
</tr>
<tr>
<td>( \hat{\beta}_2 )</td>
<td>-</td>
<td>-0.4227***</td>
<td>-0.3947***</td>
<td>-0.3465***</td>
<td>-0.1178***</td>
<td>-0.3585***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
</tr>
<tr>
<td>( \hat{\beta}_3 )</td>
<td>-</td>
<td>-0.2531***</td>
<td>-0.2307***</td>
<td>-0.3064***</td>
<td>-0.1146***</td>
<td>-0.2887***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
</tr>
<tr>
<td>( \hat{\beta}_4 )</td>
<td>-</td>
<td>0.1560***</td>
<td>0.3116***</td>
<td>0.0093</td>
<td>-0.0324***</td>
<td>-0.0457***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
<td>(0.69)</td>
<td>(&lt;0.0001)</td>
<td>(&lt;0.0001)</td>
</tr>
<tr>
<td>Adjusted ( R^2 )</td>
<td></td>
<td>0.1079</td>
<td>0.1565</td>
<td>0.4169</td>
<td>0.7284</td>
<td>0.4398</td>
</tr>
</tbody>
</table>

PANEL B: Summary of coefficient estimates and hypothesis tests:

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>R&amp;D Costs</th>
<th>Advertising Costs</th>
<th>Other SG&amp;A Costs</th>
<th>Cost of Goods Sold</th>
<th>Total SG&amp;A Costs (Model A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \hat{\beta}_{II} )</td>
<td>0.5266</td>
<td>0.6799</td>
<td>0.6648</td>
<td>0.9721</td>
<td>0.6582</td>
</tr>
<tr>
<td>( \hat{\beta}_{ID} )</td>
<td>0.1038</td>
<td>0.2852</td>
<td>0.3183</td>
<td>0.8543</td>
<td>0.2997</td>
</tr>
<tr>
<td>( \hat{\beta}_{DI} )</td>
<td>0.2734</td>
<td>0.4492</td>
<td>0.3584</td>
<td>0.8575</td>
<td>0.3695</td>
</tr>
<tr>
<td>( \hat{\beta}_{DD} )</td>
<td>0.6826</td>
<td>0.9915</td>
<td>0.6555</td>
<td>0.9397</td>
<td>0.6125</td>
</tr>
</tbody>
</table>

Test \( p\)-value
Hypothesis 1: \( \beta_{II} > \beta_{DI} \) \([\beta_1 > (\beta_1 + \beta_3)]\) \(<0.0001\)

Hypothesis 2: \( \beta_{DD} > \beta_{ID} \) \([\beta_1 > (\beta_1 + \beta_3)]\) \(<0.0001\)

Hypothesis 3: \( \beta_{II} > \beta_{ID} \) \([\beta_1 > (\beta_1 + \beta_3)]\) \(<0.0001\)

Hypothesis 4: \( \beta_{DD} > \beta_{DI} \) \([\beta_1 > (\beta_1 + \beta_3)]\) \(<0.0001\)

Notes:
1- Panel B reports the values of \( \hat{\beta}_{II} \), \( \hat{\beta}_{DI} \), \( \hat{\beta}_{DD} \) and \( \hat{\beta}_{ID} \) generated from pooled cross-sectional estimation of model C reported in Panel A.

2- The p-values reported in Panel B are tests of the null hypothesis of equality of coefficients, carried out by constraining the coefficients to be equal.

Variable Definitions:

REV is sales revenue (Compustat data12).
R&D Costs is R&D expense (Compustat data46). Advertisement costs are Compustat data45. SG&A is sales and general administrative expenses (Compustat data189). Other SG&A = (SG&A – (Advertisement + R&D))

\((\text{INCR}_{it-DECR}_{i,t-1})\) takes value of 1 when sales revenue of firm \(i\) increases in current year (between \(t\) and \(t-1\)) having decreased in previous year (between period \(t-1\) and \(t-2\)) (Corresponds to case-(I, D_{it-1}))

\((\text{DECR}_{it-INCR}_{i,t-1})\) takes value of 1 when sales revenue of firm \(i\) decreases in current year and increases in previous year (Corresponds to case-(D, I_{it-1}))

\((\text{DECR}_{it-DECR}_{i,t-1})\) takes value of 1 when sales revenue of firm \(i\) decreases in both current and previous years. (Corresponds to case-(D, D_{it-1}))

Coefficient Definitions:

\( \hat{\beta}_{II} \) = Percentage increase in costs per unit increase in sales when sales revenue increases in both current and previous periods. (\( \hat{\beta}_{II} = \hat{\beta}_1 \) in model C)

\( \hat{\beta}_{DI} \) = Percentage decrease in costs per unit decrease in sales when sales revenue decreases in the current period having increased in the previous period. (\( \hat{\beta}_{DI} = \hat{\beta}_1 + \hat{\beta}_3 \) in model C)

\( \hat{\beta}_{ID} \) = Percentage increase in costs per unit increase in sales when sales revenue increases in the current period having decreased in the previous period. (\( \hat{\beta}_{ID} = \hat{\beta}_1 + \hat{\beta}_2 \) in model C)

\( \hat{\beta}_{DD} \) = Percentage decrease in costs per unit decrease in sales when sales revenue decreases in both current and previous periods. (\( \hat{\beta}_{DD} = \hat{\beta}_1 + \hat{\beta}_4 \) in model C)