MODELING COST BEHAVIOR: LINEAR MODELS FOR COST STICKINESS

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ABSTRACT

Literature acknowledges that costs might not be linear and proportional with activity levels. However, conjectures about the sticky behavior of costs are largely based on anecdotal and empirical evidence despite sufficiently advanced economic theory that explains cost behavior (Cooper and Kaplan, 1998; Noreen and Soderstrom, 1997; Banker and Johnston, 1993). For instance, while Noreen and Soderstrom (1997) find no evidence of stickiness, Anderson, et al (2003) find that SG&A costs are sticky – that is, they increase, on the average, by 0.55% per 1% increase in revenues, but decline by 0.35% per 1% decrease in revenues. Subramaniam and Weidenmier (2003) confirm cost stickiness, finding that total cost increase 0.93% per 1% increase in revenues but decrease only by 0.85% per 1% decrease in revenues. Both studies used data from US firms.

This paper derived a basic cost behavior model and used this model to test whether asymmetric cost behavior in Philippine firms is also prevalent, using different linear models such as OLS and GLS regression analyses. It concluded that GLS regression analysis is not more efficient than OLS regression analysis.

INTRODUCTION

The relationship between cost and activity has always baffled business executives. While it was commonly accepted that there exist a relationship between the two, literature has not clearly explained the relationship. Some costs are acknowledged to move linearly and proportionally with activity levels while others don't. In more recent studies, the issue of symmetric movement of costs with respect to activity level changes was also discussed. Anderson, Banker and Janakiraman (2003) coined the term "sticky" costs to describe what they discovered as asymmetric cost behavior with respect to activity levels.

To shed light on this topic, I will first derive a basic cost behavior model which will allow us to test asymmetric cost behavior in firms. Next I will use Philippine company data from 2004 to 2008 and run different linear models, particularly OLS and GLS regression analyses and discuss the results for each. By way of conclusion, I will present which liner cost model is more efficient

PART 1: BASIC COST BEHAVIOR MODEL

1.1 Deriving the cost behavior Model

To model cost behavior using economic theory, we start by deriving the cost-volume-relationships from the cost and production function. This will provide economic grounding which underlies the sticky cost hypothesis and the economic models used to test it.

The cost function relates total cost (c) to factor prices (pj) and output quantity (y). In competitive markets, factor prices and output quantity are exogenous. A widely used production function in economics is the Cobb-Douglas production function:

$$y_1 = f(x_{1t}, x_{2t}) = A_t \cdot x_{1t}^{\alpha} x_{2t}^{\beta} \tag{1}$$

where t is a time index, At is a positive constant, xjt , j=1,2 are input factors and α, β are positive, time-invariant fractions that add up to one which implies constant returns to scale. The corresponding Cobb-Douglas cost function is:

$$c_t(y_t) = K_t y_t^{1/(\alpha+\beta)} \tag{2}$$

where Kt is a function of factor princes (pj), At, α and β.The cost growth between t-1 and t can be expressed as

$$\frac{c_t(y_t)}{c_{t-1}(y_{t-1})} = \frac{K_t}{K_{t-1}}\left(\frac{y_t}{y_{t-1}}\right)^{1/(\alpha+\beta)} \tag{3}$$

If we take the log of both sides and (implicitly) assume that factor prices are constant over time, we are able to derive an empirical model shown as equation (4) below. If we do not assume constant factor prices, our model will suffer from omitted variable bias, unless we consider factor prices in our empirical estimation.

$$\log\left(\frac{c_t}{c_{t-1})}\right) = \gamma_0 + \gamma_1 \log\left(\frac{y_t}{y_{t-1}}\right) + \varepsilon_t \tag{4}$$

with $\gamma_0 = \log\left(\frac{K_t}{K_{t-1}}\right)$, $\gamma_1 = \frac{1}{\alpha+\beta}$, and ε_t being a zero mean error term.

This model is consistent with our traditional fixed- and variable-cost model. Traditional model assumes that variable costs change proportionately with the changes in activity level which implies a constant returns to scale, $\gamma_1 = 1$ since $\alpha + \beta = 1$. Moreover, the model assumes that the change in variable costs is invariant to the direction of the change in volume. Thus, the cost-volume-relationship is symmetric for volume increases and decreases, implying that γ_1 is equal in both cases.

However, this runs counter to the recent empirical studies (Anderson, et al, 2003; Calleja, 2005; Anderson and Lanen, 2007) which provide evidence that certain cost types, particularly SG&A costs, behave in an asymmetric manner. They rise more with increases in volume than they fall with decreases in volume thereby implying that γ_1 should be higher for increases that for decreases in activity level. Extant literature defines this asymmetric cost behavior with respect to directions in volume changes as sticky cost or cost stickiness, and typically uses SG&A costs instead of total cost and sales instead of volume to test this behavior.

It is interesting to point out that while Anderson et al. (2003) whose study introduced us to the concept of cost stickiness, explain their measurement choice with a lack of large datasets on activity levels and total costs, Anderson and Lanen (2007) warn that changes in sales is not an exogenous regressor because in addition to volume, sales depend on prices, which are set by management. Anderson and Lanen (2007) also point out that the classification of costs is subject to managerial choice and that SG&A represents only about 30% of total cost. Consequently, these create measurement problems for investigating cost behavior.

In any case, to test the sticky cost hypothesis, we extend equation (4) to allow different slopes for positive and negative volume changes, shown as equation (5) below.

$$\log\left(\frac{c_t}{c_{t-1}}\right) = \gamma_0 + \gamma_1 \log\left(\frac{y_t}{y_{t-1}}\right) + \gamma_2 D_t \log\left(\frac{y_t}{y_{t-1}}\right) + \varepsilon_t \qquad (5)$$

where $D_t = 1$ if $\Delta y_t < 0$, and $D_t = 0$ if $\Delta y_t > 0$.

We then use Anderson et al's 2003 measurement choices and substitutes to yield equation (6) below:

$$\log\left(\frac{SG\,\&\,A_t}{SG\,\&\,A_{t-1}}\right) = \gamma_0 + \gamma_1 \log\left(\frac{SALES_t}{SALES_{t-1}}\right) + \gamma_2 D_t \log\left(\frac{SALES_t}{SALES_{t-1}}\right) + \varepsilon_t \qquad (6)$$

where $D_t = 1$ if $\Delta SALES_t < 0$, and $D_t = 0$ if $\Delta SALES_t > 0$.

The coefficient, γ_1, measures the percentage increase in SG&A costs with a 1% increase in sales, while the combined coefficients, $(\gamma_1 + \gamma_2)$ measures the percentage decrease in SG&A costs with a 1% decrease in sales. In the traditional fixed- and variable-cost model, it proposes that total cost changes are invariant to the direction of the change in activity, which means that $\gamma_2 = 0$. This was refuted by Anderson et al. (2003) when they found that on the average, cost increase by 0.55% per 1% increase in sales, but decline by 0.35% per 1% decrease in sales, thus $\gamma_2 < 0$.

1.2 Explaining cost stickiness

Literature has identified three major factors that contribute to the asymmetry in SG&A costs with respect to increases and decreases in sales revenue.

First is the fixity of SG&A costs. When a portion of SG&A costs is fixed and sales decline, the ratio between SG&A costs and sales increases, because the fixed capacity costs are spread over a lower sales level. This includes also costs which are contractual in nature which cannot be discontinued with decreases in sales volume.

The next two factors are related to the part of SG&A costs that are variable. Second, when the level of activity declines, the manager decides whether to adjust capacity in order to reduce variable SG&A costs. If the manager maximizes the value of the firm, he will trade off the costs of maintaining excess resources against the adjustment costs of cutting existent resources and building them up again, when demand is restored. His decision depends on his expectation of future demand and on the uncertainty of his expectation. If the manager expects demand to restore sufficiently fast in future periods, adjustment costs will be higher than the costs of unutilized capacity and he will decide to maintain excess resources. Similarly, if the uncertainty about future demand is high and cutting committed resources costly, the manager will decide to wait in order to obtain more information before incurring adjustment costs. The asymmetry in costs induced by the economic decision to bear the costs of excess resources is defined as cost stickiness.

Third, an asymmetric cost behavior with respect to sales increases and decreases will also arise, if the manager maintains excess capacity maximizing his own utility function, whereas the firm value maximizing decision would be to cut recourses. In this case, the manager expects a permanent decline in future demand yet, he decides to keep capacity because he incurs a higher disutility with understaffing than with overstaffing. For example, in the case of managerial empire building, managers might be willing to maintain unutilized resources for reasons such as status, prestige and power (Jensen and Meckling, 1976; Hope and Thomas, 2007) Another reason why managers might be reluctant to cut resources, particularly staff, is when they face considerable public pressure with regard to their social responsibility.

Stickiness might also be affected by the systems of corporate governance and managerial oversight. In the US and UK, for instance, the common law system of corporate governance puts more emphasis on the notion of shareholder maximization and on the role of the stock market as a means of achieving that objective. The stock market is also the mechanism through which the market for corporate control operates to discipline underperforming management. Thus, management comes under external pressure to make decisions in the interest of shareholders.

In contrast, the systems of corporate governance in France and Germany, rather than being exclusively directed at shareholder levels, are directed at a coalition of external and internal interest groups. This then carries over to an increased role of co-determination between management, workers, and fund providers in the allocation of resources. O'Sullivan (2003) describes this regulatory framework in France as one "which provides more social protection to their workers than is the case in the US. There are, for instance, substantial costs to French enterprises downsizing their labor forces". He likewise recognized a broadly similar governance framework of co-determination existing in Germany where firm employees sit either on the Supervisory Board (the Aufsichtsrat) or the factory council (the Betriebsrat). Both of these councils have "the capacity to negotiate wages, job security and other aspects of the age relationship that is largely absent in countries such as US and UK".

Because of these features (the higher relative cost of cutting back resources, the level of external oversight of managerial behavior, and the focus on stakeholders rather than shareholders) may largely affect cost stickiness in not only in French and German firms in particular but in firms with these governance systems in general.

PART 2: TESTING COST STICKINESS

2.1 Data Description

The primary variables used in my analysis are SG&A costs and sales revenues. The dataset I used includes annual data for listed Philippine firms belonging to 17 industries covering 5 years from 2004 and 2008. I screened the data for missing observations in SG&A or sales revenue in the current and preceding year and deleted observation if SG&A costs exceeded sales revenues. The total number of remaining observations is 634 for 173 firms, an average of 3.62 observations per firm.

Table 1 provides descriptive information about the annual revenues and SG&A costs for the observations included in the dataset. The mean value of SG&A costs as a percentage of sales is 87.68% with median of 91.48% and standard deviation of 90.91%. Panel B provides information about the frequency of firm-years when revenue fell (relative to the previous year) and firm-years when SG&A fell. Revenue fell in 30.18% of the annual firm-years in the sample and SG&A fell 29.86%. The mean value of revenue decrease is 23.21% with median of 16.21% and standard deviation of 23.98%, and the mean value of decreases in SG&A is 23.48% with a median of 19.56% and standard deviation of 22.54%.

Table 1
Summary Statistics
All reported numbers are in P'000 except the percentages

Panel A: Distribution of Annual Revenue and SG&A Costs from 2004 to 2008

	Mean	Median	Standard Deviation
Sales Revenues	10,429,453	1,178,591	29,449,055
Selling, general and administrative (SG&A) costs	9,144,041	1,078,127	26,773,433
SG&A costs as a percentage of revenues	87.68%	91.48%	90.91%

Panel B: Periodic Fluctuations in Revenues and SG&A from 2004 to 2008

	% of firm-years with negative % change	Mean % decrease across periods	Median % decreases across periods	Standard Deviation of % decreases across periods
Sales revenues	30.18%	23.31%	16.21%	23.98%
SG&A costs	29.86%	23.48%	19.56%	22.54%

2.2 OLS Estimation

Table 2
Summary Statistics (Stata 9.1)

Variable	Obs	Mean	Std. Dev.	Min	Max
ind	0				
company	0				
code	0				
period	0				
year	623	2006.48	1.112267	2005	2008
rev	0				
sga	0				
chrev	623	2.485933	14.11497	.0032409	289.6435
chsga	623	1.462878	3.118156	.0042049	45.83112
d1	623	.3017657	.459393	0	1
logrev	623	.0584909	.3384822	-2.489328	2.461864
logsga	623	.0463923	.2505392	-2.376239	1.66116
d1logrev	623	-.0525206	.1977846	-2.489328	0
d2	623	.2985554	.4579921	0	1

Using the model in equation (6) applied on a cross-sectional analysis of a wide variety of industries and large differences in the size of firms. Because of this, the ratio form and the log specification improve the comparability of the variables across firms and alleviates potential heteroskedasticity. Empirically, the Davidson and MacKinnon test rejects the linear form in favor of this log-linear model.

Table 2 shows the summary statistics of the data set used for this testing the cost behavior model in equation (6) above.

The OLS regression yielded the following estimator as shown in equation (7).

$$\log\left(\frac{SG\,\&\,A_t}{SG\,\&\,A_{t-1}}\right) = 0.012 + 0.527\log\left(\frac{SALES_t}{SALES_{t-1}}\right) - 0.066 D_t \log\left(\frac{SALES_t}{SALES_{t-1}}\right) + \varepsilon_t \qquad (7)$$

The coefficients γ_0, γ_1 and γ_2 are consistent with a priori expectations but γ_2 is significant only at 81.1% confidence level as summarized in Tables 3 below.

Table 3
Summary Results (OLS Estimates)

Coefficient	A Priori	Coefficient Estimates	P-Value
γ_0	+	0.0120864	0.151
γ_1	+	0.5269526	0.000
γ_2	-	-0.0663348	0.189

Furthermore, these results show that there is a weak evidence of a sticky cost behavior particularly for the sample of public listed firms in the Philippines covered by the study. More particularly, SG&A costs increase by 0.5270% for every 1% increase in sales, while it decreases 0.4607% for every 1% decrease in sales. Table 4 presents the OLS estimation results using Stata 9.1.

Table 4
Regression Results: OLS

```
regress logsga logrev d1logrev

      Source |       SS       df       MS              Number of obs =     623
-------------+------------------------------           F(  2,   620) =  263.54
       Model |  17.9402269     2  8.97011346           Prob > F      =  0.0000
    Residual |  21.1026605   620  .034036549           R-squared     =  0.4595
-------------+------------------------------           Adj R-squared =  0.4578
       Total |  39.0428874   622  .062769915           Root MSE      =  .18449

------------------------------------------------------------------------------
      logsga |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      logrev |   .5269526   .0294952    17.87   0.000       .46903    .5848753
    d1logrev |  -.0663348   .0504772    -1.31   0.189    -.1654618    .0327921
       _cons |   .0120864   .0084131     1.44   0.151    -.0044353    .0286081
------------------------------------------------------------------------------
```

Testing for any specification errors also show that the above model is robust and free from heteroskedasticity using BP/CW test. This supports White's test which concluded that heteroskedasticity was not a problem for the loglinear model. To determine whether the model has committed the violation of multicollinearity or the presence of a linear relationship among the variables, I performed the Variance Inflation Factor (VIF) Criterion Test, which states that if any VIFj, where j = 2,3,…k, and k = the number of treatments (independent variables), has a VIF value greater than 10, there is an evidence of multicollinearity and correcting actions should be directed towards removing the erring variable or retaining it if an error of omission will take place. The computed VIF for the model passed this criteria. Lastly there was also no omitted variables in the model as shown by the Ramsey test. The results of these test are shown in Table 5.

Table 5
Specification Tests
Test for Heteroskedasticity

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of logsga

         chi2(1)      =    12.98
         Prob > chi2  =   0.0003
```

Test for Multicollinearity

Variable	VIF	1/VIF
d1logrev	1.82	0.549010
logrev	1.82	0.549010
Mean VIF	1.82	

Test for Omitted Variables

```
Ramsey RESET test using powers of the fitted values of logsga
       Ho:  model has no omitted variables
                 F(3, 617) =      2.16
                  Prob > F =      0.0918
```

2.3 GLS Estimation

In this section, I present the results of the GLS estimation. The GLS or generalized least squares estimator makes stronger distributional assumptions about the variance of the error term in our model (equation 6). However, it is nonetheless possible to obtain standard errors of GLS estimator that are robust to misspecifications of error variance just as in the OLS case.

Interestingly, we can note that the resulting estimation of the model is similar to the OLS model. Specifically, we see that the coefficients γ_0, γ_1 and γ_2 are consistent with a priori expectations. They are significant except for γ_2 which is significant only at 81.1% confidence level. This signifies that the OLS is still the best linear unbiased estimator for our cost behavior model. Stata results are shown in Table 6..

Table 6
Regression Results: GLS Estimates

```
Iteration 0:   log likelihood =  170.47471

Generalized linear models                          No. of obs      =        623
Optimization     : ML                              Residual df     =        620
                                                   Scale parameter =   .0340365
Deviance         =  21.10266048                    (1/df) Deviance =   .0340365
Pearson          =  21.10266048                    (1/df) Pearson  =   .0340365

Variance function: V(u) = 1                        [Gaussian]
Link function    : g(u) = u                        [Identity]

                                                   AIC             = -.5376395
Log likelihood   =   170.474708                    BIC             = -3968.316
```

logsga	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
logrev	.5269526	.0294952	17.87	0.000	.4691431	.5847622
d1logrev	-.0663348	.0504772	-1.31	0.189	-.1652683	.0325986
_cons	.0120864	.0084131	1.44	0.151	-.0044031	.0285758

CONCLUSION

In this study, I found weak support that SG&A costs exhibit sticky behavior for listed Philippine firms. On the average across all firm-years in my observations, SG&A costs increased around 0.5270% for every 1% increase in sales but decline only 0.4607% per 1% decrease in sales. This is consistent with the alternative cost behavior model that takes into account the asymmetric friction created by managers when adjusting committed resource following changes in the level of activity of the firm albeit to a limited sense.

From a modeling standpoint, we see that since there is no need for robust standard errors to be used for efficiency gains, then the GLS estimator is not more efficient than the OLS estimator (i.e. both show the same results). By showing these, we were able to simulate the Gauss-Markov theorem using Philippine data.

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