

Non Linear Speed of Adjustment to Lead Leverage Levels: Empirical Evidence from Firm Level Data

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Abstract

This paper tests the speed of adjustment of lag leverage levels (actual) to lead levels (target) levels using partial adjustment models based on the dynamic trade-off view of capital structure. We estimate baseline speed of adjustments for first differences to the first difference of modelled lead levels from lag levels of firm level leverage for a sample of UK firms. In line with our expectations derived from the literature, we find that the adjustment speed is faster when lag levels exceed lead levels relative to when lead levels exceed lag levels. Dissecting the motivation of this paper further we find that our results do not hold when the differences of firms above and under target levels are large. Thus although initial findings provide support for the expectation in the literature, we find that the theory does not hold when tested further suggesting that a more dynamic framework would be necessary to best explain target adjustment behavior.

Keywords: First Differences Adjustment Behavior, Lead-Lag Relationship, Speed of Adjustment.

1. Introduction

Our paper tests the speed of adjustment to lead levels using a sample of UK firms. The test distinguishes actual time dimension values which are above and under lead values, similar to Byoun¹. However, we dissect the results further to evaluate the extent of difference between actual time values to lead values. We show that differing velocity of adjustment is observed and is a function of the difference in itself.

Given that firms often deviate from lead levels due to the impediment of adjustment costs, the speed of adjustment should be dependent on the magnitude of the first difference. However, our paper distinguishes the extent of deviation and finds strong empirical evidence to support our notion. Thus, our paper shows that speed of adjustment to target levels works in a non-linear manner.

The paper is structure as follows: the section below briefly discusses the relevant literature and provides the motivation for our study. Next, we describe the data, define all variables and provide our empirical model.

Following on, we present and discuss the findings. The last section concludes the paper.

2. Review of the Literature and Motivating the Study

In this section we briefly discuss the literature on the speed of adjustment debate which centres on the dynamic trade-off theory of capital structure. The literature provides significant contention on the speed of adjustment motivating our paper to look at the extent of deviation of actual values from lead values and based on the difference between lead and lag values.

Firms deviate from target levels and adjustment costs as well level of analyst coverage impede rapid adjustment to target levels as discussed in Leary and Roberts² and Chang et al³. In addition the cost of being above target levels exceed the cost of deviating below target levels as evidenced in Byoun¹ and Binsbergen et al.,⁴ and thus firms above tend to adjust faster than firms below targets.

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3. Variables and Methodology

3.1 Description of Sample

Our initial sample includes all UK firms available in the Datastream Thomson Reuters database. We utilize a period of 20 years (1993 – 2012). In order to avoid survivorship bias, we include dead firms and consistent with the literature we exclude financial firms. All observations are based on the financial year-end of each individual firm and all variables are winsorize at the 1st and 99th percentile to eliminate outliers. The two-step system GMM approach to estimate baseline speed of adjustment imposes a survivorship bias of 4-years in our sample. In addition, we drop observations with missing data. The final sample comprises of 1,468 firms with 15,892 firm-year observations. Table 1 below summarizes firms specific characteristics.

Table 1. Descriptive statistics of the sample

Variable	Mean	Median	Standard Deviation
BL	0.1806	0.1629	0.1742
ML	0.2086	0.1659	0.2224
SIZE	10.561	9.386	2.146
MTB	1.724	1.385	1.165
TANG	0.3648	0.3068	0.2365
R&D	0.0314	0.0208	0.0587

3.2 Estimation Methods

The analysis in this paper is based on unbalanced panel data to allow efficient estimates of our model due to econometric efficiency, increase the inference of model parameters and control for omitted variable bias. All variables in this study mirror definitions in previous studies.

Firms' SIZE is the natural logarithm of net sales in millions of 1993 pounds. TANG, asset tangibility is net plant, property and equipment over total assets. R&D (research and development expenses) is scaled by total assets. The market-to-book ratio (MTB) is defined as Ratio of book value of total assets less book value of equity plus market value of equity (M) to book value of total assets (B).

Our empirical model of the lead variable (*Target Lverage_{t+1}*) based on the static model of Fama and French⁵ as well as the dynamic model of Blundell and Bond⁶ is aimed at measuring the speed of adjustment to target leverage subject to the extent of deviation from

target levels. Similar to Flannery and Rangan⁷, we utilize the following model to measure speed of adjustment as follows:

$$Lverage_{it+1} - Lverage_{it} = [\alpha][\beta][Target \ Lverage]_{it+1} - Lverage_{it} - e_{t+1} \quad (1)$$

where *Lverage_{it+1}* is the debt ratio in period *t+1* for firm *i*, and *Target Lverage_{it+1}* is the target leverage ratio in period *t+1* for firm *i*. The difference between the two variables is the amount the debt ratio must change to allow firms to be back on target. Derived from the work of Fama and French⁵, Blundell and Bond⁶ as well as Warr et al.⁸, our study uses a 2-stage model to estimate speed of adjustment. Furthermore, similar to Flannery and Rangan⁷, the use of two differing methods for estimating speed of adjustment is for robustness purposes and is able to tackle dynamic panel data bias.

The second stage uses the target leverage ratios bifurcated from equation (2). In addition, drawing from Hovakimian et al.⁹ and Hovakimian and Li,¹⁰ our model controls for firms specific characteristics to estimate *Target Lverage_{it+1}* and estimates both book leverage (BL) as well as market leverage (ML) whilst lagging all control variables by 1 to control for endogeneity concerns. Our model is as follows and includes 15 industries dummies (1,0) based on Hussain¹¹:

$$Target \ Lverage_{it+1} = [\alpha][\beta]_1 CONT_{it} + [\alpha][\beta]_2 SIZE_{it} + [\alpha][\beta]_3 MTB_{it} + [\alpha][\beta]_4 TANG_{it} + [\alpha][\beta]_5 R\&D_{it} + [\alpha][\beta]_6 RDD_{it} + [\alpha][\beta]_7 INDL_{it} + [\alpha][\beta]_{it+1} \quad (2)$$

Industry classifications are shown in Appendix A. In addition, similar to Alt¹², we include a RDD dummy variable which takes the value of 0 when firms research and development expenses are not available. To further control for specific target levels at industry level, we include the *INDL_{it}* variables which is the industry median leverage at time *t* for firm *i*. The second method utilizes a 2-step system GMM estimator based on Blundell and Bond.⁶ In addition the standard errors used to measure significance levels are robust to heteroscedasticity whilst for correcting for finite sample errors as proposed in Windmeijer¹³.

4. Results and Discussion

The results for estimating equation (1) derived from Fama and French⁵ as well as Fama and MacBeth¹⁴, are reported in Table 2 which reports the coefficients and standard

Table 2. Estimating target leverage at the lead level based on the static framework.

	1	2
CONST	-0.084*** (0.0268)	-0.0484 (0.0368)
SIZE	0.0206*** (0.0018)	0.0217*** (0.0029)
MTB	-0.0061*** (0.0029)	-0.0848*** (0.0061)
TANG	0.1053*** (0.0145)	0.1102*** (0.0206)
R&D	0.0042 (0.0218)	0.0113 (0.0129)
RDD	0.0405*** (0.0098)	0.0712*** (0.0253)
INDL	0.4927*** (0.0891)	0.7944*** (0.2068)
Average R ²	0.1758	0.2241
F – Test (p-values)	0.00	0.00
Observations	15,892	15,892
Period	1993 – 2012	1993 – 2012

Note: ***, ** and * indicates significance at 1%, 5% and 10% respectively.

errors in parenthesis. Column 1 uses book leverage as the dependent variable which is replaced by market leverage in column 2.

Our results are in line with expectations based on Flannery and Rangan⁷, Warr et al.⁸ and Hovakimian et al.⁹ Table 3 further reports the results for regression for equation (2).

The results from Table 3 further confirm that firms adjust toward target levels as the lagged leverage variable is significant statistically and economically. The simulated values from the results in table 2 and 3 are then used to estimate the speed of adjustment based on the distance from target leverage and is modelled as per Warr et al.⁸

$$Lverage_{it+1} - Lverage_{it} = [\alpha][\alpha]_1 CONT_{it} + [\alpha][\alpha]_2 (Target\ Lverage_{it+1} - Lverage_{it}) + [\alpha][\alpha][Explanatory\ Variables]_{it} + [\alpha][\alpha]_{it+1} \quad (3)$$

Our model measures the DIST ($Target\ Lverage_{it+1} - Lverage_{it}$) which is the amount leverage level must change in order to allow firms to revert to target leverage levels. Thus, firms which are above their target levels

Table 3. Estimating target leverage at the lead level based on the dynamic framework

	1	2
LEVERAGE	0.5728*** (0.028)	0.7428*** (0.0218)
SIZE	0.0248*** (0.0062)	0.0365*** (0.0075)
MTB	-0.0024 (0.0066)	-0.0048 (0.0073)
TANG	0.0846*** (0.0206)	0.1257*** (0.0261)
R&D	0.0024 (0.0206)	0.0041 (0.0187)
RDD	0.0316 (0.0298)	0.0267 (0.0327)
INDL	0.4651*** (0.1027)	0.6455*** (0.1822)
Adjusted R ²	0.5123	0.6457
Wald test (p-values)	0.00	0.00
Sargan test (p-values)	0.29	0.24
Observations	15,892	15,892
Period	1993 – 2012	1993 – 2012

Note: ***, ** and * indicates significance at 1%, 5% and 10% respectively.

have a negative distance and firms which are below their target levels have a positive distance. If firms adjust fully to target leverage levels in the following year, the value of $[\alpha][\alpha]_2$ will be 1. We split our sample into firms which are below their target leverage levels and above target levels and run the below model.

$$Lverage_{it+1} - Lverage_{it} = [\alpha][\alpha]_1 CONT_{it} + [\alpha][\alpha]_2 (DIST)[\alpha][\alpha] LOWUNDOR LOWUOV + [\alpha][\alpha][Explanatory\ Variables]_{it} + [\alpha][\alpha]_{it+1} \quad (4)$$

The results for regressing the model in equation (4) are reported in table 4.

We report the results for regressing equation (4) in table 4 above. In order to remove any potential omitted firms factors which are time invariant leading to spurious correlation between the rate of adjustment to distance, the regression model controls for unit of observation (firm level) fixed effects.

Table 4. Non-linear speed of adjustment using interaction with distance variable

	1		2		3		4
	Under-levered firms				Over-levered firms		
Panel A: Estimating target leverage _{t+1} using static framework							
DIST x LOWUND	0.3644 ***		0.4268 ***		-		-
	(0.0246)		(0.0317)		-		-
DIST x LOWOV	-		-		0.5987 ***		0.6498 ***
	-		-		(0.0718)		(0.1107)
Adjusted R ²		0.6422		0.6829		0.5213	0.5861
Wald (p-values)		0.00		0.00		0.00	0.00
Observations		7,208		7,208		7,954	7,954
Period		1993 – 2012					
Panel B: Estimating target leverage _{t+1} using dynamic framework							
DIST x LOWUND	0.4458 ***		0.5127 ***		-		-
	(0.0471)		(0.0725)		-		-
DIST x LOWOV	-		-		0.6521 ***		0.7124 ***
	-		-		(0.1022)		(0.1458)
Adjusted R ²		0.6428		0.6625		0.5162	0.5632
Wald (p-values)		0.00		0.00		0.00	0.00
Observations		7,644		7,644		7,148	7,148
Period		1993 – 2012					

Note: ***, ** and * indicates significance at 1%, 5% and 10% respectively.

In addition this method further allows us to control for unit specific differences which are also time invariant such as the possibility of potential bias that is introduced over the period of observation arising from shocks in the economy as well as a particularly talented management team of a firm.

The standard errors reported in parentheses are based on clustering on a 2-dimensional approach (both for i and t): t in our sample is firm year and i is the specific firm.

This approach allows us to simultaneously control correlation across firms in a given period as well as correlation across time for a given firm. Our results are robust to controlling for 1-dimensional clustering as proposed in Rogers¹⁵, as well as robust standard errors to control for heteroscedasticity as discussed by White¹⁶.

In columns 1 and 2, we include the interaction term and the results are significant for the interaction term, which supports results in Byoun⁴. Given the main notion

of the paper which is motivated in the above text, we include a dummy to capture the effect of high levels of deviation from target levels. The third and fourth column shows that the distance variable the interaction term remains significant.

Thus, bulk of the adjustment to target level only occurs when the first differences are not large and firms do not significantly deviate from target levels. The results are robust to estimating target leverage on both the static Fama and French⁵ as well as the dynamic Blundell and Bond⁶ framework. The results indicate that the adjustment to target levels is only significant if the distance levels are slightly over or under target levels as indicated by the interaction term being significant.

Thus, firms only adjust target levels are rapid rates only for certain circumstances hence further confirming our hypothesis. This indicates that although the speed of adjustment varies for differing distance levels, the relationship is non-linear. Therefore, the rate of adjustment remains puzzling and the explanation is not as simple as suggested by the dynamic framework of the trade-off theory.

5. Conclusion

Our paper uses unbalanced panel data of UK firms to test the adjustment to target leverage levels. The main notion of the paper is that the speed of adjustment to target levels work in a non-linear manner. Drawing from the literature, we utilize a two-stage approach to estimate the speed of adjustment to lead (target) levels. The first stage is further estimated using a static and dynamic approach. The second stage then models the difference between the simulated lead (target) level and the lag (current) level of leverage to the difference between the actual lead (target) level and the actual lag (current) leverage levels. Our initial findings confirm the established evidence in the literature. Further analysis however indicates that the increase in leverage levels when firms are below target levels is only evident when the distance is relatively smaller. Conversely, when looking at firms which are above target levels; we find that adjustment to target levels only occur when distance levels are not severely above theoretical predictions. Overall, our results indicate that extent of distance in itself influences speed of adjustment in a non-linear manner. However, our analysis does not consider the interplay between difference factors affecting

adjustment to target levels such as information asymmetry as well as preserving financial slack; providing a plausible direction for future researches in understanding how distance to target levels influences speed of adjustment and the extent of integration of several explanations of capital structure to explain rates of adjustment.

6. References

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Appendix

Industry classifications	
No	Industry Name
1	Automotive, Aviation and transportation
2	Beverages, Tobacco
3	Building and Construction
4	Chemicals, Healthcare, Pharmaceuticals
5	Computer, Electrical and electronic equipment
6	Diversified industry
7	Engineering, Mining, Metallurgy, Oil and gas exploration
8	Food producer and processors, Farming and fishing
9	Leisure, Hotels, restaurants and pubs
10	Other businesses
11	Paper, Forestry, Packaging, Printing and publishing, Photography
12	Retailers, Wholesalers and distributors
13	Services
14	Textile, Leather, Clothing, Footwear and furniture
15	Utilities
<i>Source: Thomson Reuters Datastream</i>	