THE WEIGHTED AVERAGE COST OF CAPITAL OVER THE LIFECYCLE OF THE FIRM: IS THE OVERINVESTMENT PROBLEM OF MATURE FIRMS INTENSIFIED BY A HIGHER WACC?

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Abstract

Firm lifecycle theory predicts that the Weighted Average Cost of Capital (WACC) will tend to fall over the lifecycle of the firm (Mueller, 2003, p. 80-81). However, given that previous research finds that corporate governance deteriorates as firms get older (Mueller and Yun, 1998; Saravia, 2014) there is good reason to suspect that the opposite could be the case, that is, that the WACC is higher for older firms. Since our literature review indicates that no direct tests to clarify this question have been carried out up till now, this paper aims to fill the gap by testing this prediction empirically. Our findings support the proposition that the WACC of younger firms is higher than that of mature firms. Thus, we find that the mature firm overinvestment problem is not intensified by a higher cost of capital, on the contrary, our results suggest that mature firms manage to invest in negative net present value projects even though they have access to cheaper capital. This finding sheds new light on the magnitude of the corporate governance problems found in mature firms.

Keywords: WACC, Firm Lifecycle, Corporate Governance, Overinvestment

1. INTRODUCTION

Previous research on corporate governance and firm investment performance has found that, contrary to the observed behavior of young companies, mature firms tend to invest in projects with rates of return below their Weighted Average Cost of Capital (WACC). Moreover, these studies have concluded that the ultimate reason for the overinvestment problem is the breakdown of corporate governance mechanisms in mature firms (Mueller and Yun, 1998; Saravia, 2014). Now, given these findings of poor corporate governance in older firms, the question remains whether the overinvestment problems observed in mature firms may also be due to a potentially higher WACC for these firms.

The lifecycle theory of the firm, on which the above mentioned research rests, predicts that the WACC will tend to fall over the lifecycle of the firm (Mueller, 2003, pp. 80-81). Although this is a sensible proposition, we find that no direct empirical tests on the trend of the WACC over the lifecycle of the firm have been undertaken until now. Importantly, since firm lifecycle theory states that when mature firms overinvest this causes both existing and potential shareholders to require a higher rate of return from then on, it is not *a priori* certain that the WACC of mature firms with such governance problems should be lower than that of young firms as submitted by the theory. Thus, a key objective of this paper is to fill this gap in the literature by testing empirically whether the WACC falls over the lifecycle of the firm as put forward by firm lifecycle theory.

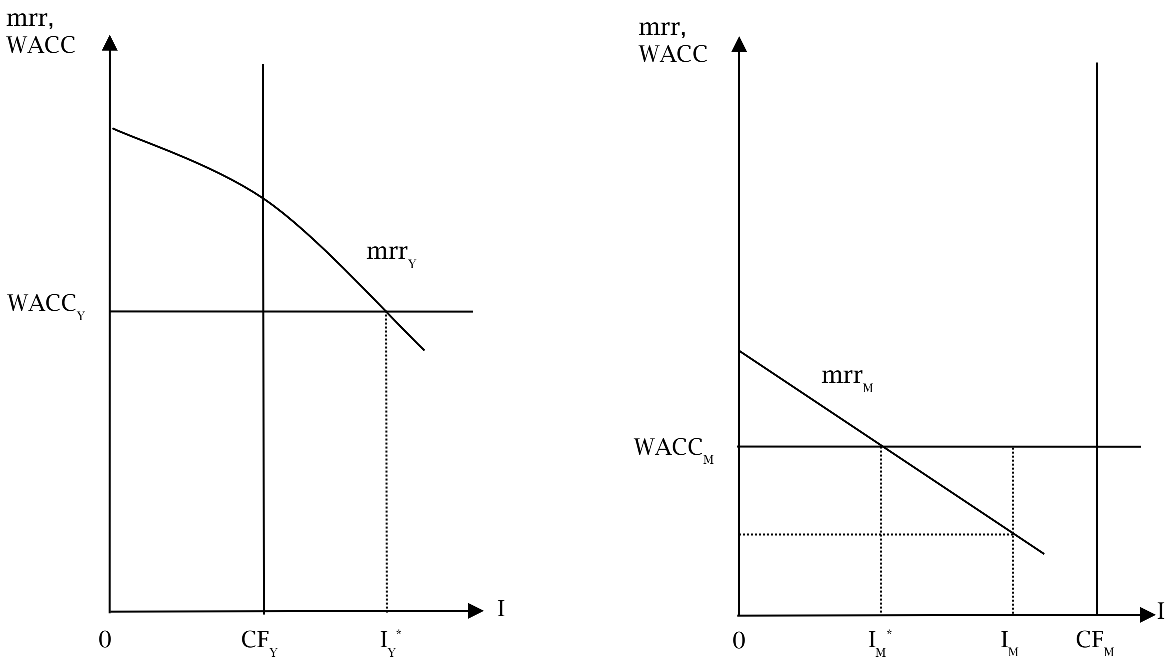
The importance of this paper is twofold. Firstly, as indicated above, empirical work on the tendency of the WACC over the lifecycle of the firm is nonexistent and, to the best our knowledge, ours is the first paper that investigates this issue empirically. The previous work that comes closest to examining this topic is the empirical paper by Hasan, Hossain and Cheung (2015) who study the trend of the cost of equity over the lifecycle of Australian firms. These researchers find that the cost of equity has a tendency to fall as firms get older. However, they do not extend their research to investigate the behavior of the WACC over the lifecycle of the firm. Secondly, ours is the first paper that investigates empirically whether the overinvestment problems observed in mature firms are intensified by a higher WACC. In this paper we collect data on the WACC and other firm characteristics for a sample publicly listed of U.S. non-financial corporations over the 2000-2013 time period. After performing econometric tests, we find support for the proposition that the WACC of younger firms is significantly higher when compared to that of mature firms. As mentioned above, since Mueller and Yun (1998) and Saravia (2014) find that mature firms have poor corporate governance since they tend to overinvest in projects with rates of return below their WACC, our findings suggest that a higher cost of capital is not a contributing factor to the problem, on the contrary, our results suggest that mature firms manage to invest in negative present value projects despite their having access to cheaper sources of capital. This observation sheds new light on the magnitude of the corporate governance problems found in mature firms, since it suggests that mature firms are destroying value by overinvesting in projects with some of the lowest rates of return in the economy.

The remainder of this paper is organized as follows: Section 2 reviews the lifecycle theory of the firm and develops testable propositions. Section 3 discusses our econometric specification. Section 4 presents our data sources, describes the sample, and discusses and documents our results. Section 5 concludes the paper.

2. THE LIFECYCLE THEORY OF THE FIRM AND THE WACC

Taking as his starting point the contribution of Schumpeter (1934, 1943) that firms have a lifecycle, Mueller (1969, 1972, 2003, pp. 81-83) develops a firm lifecycle theory that focuses on the capital budgeting and cost of capital situations that firms face as they go through their lifecycles. We can best summarize Mueller's theory with the aid of Figure 1.

Figure 1. The WACC over the lifecycle of the firm.



a) Young firm

b) Mature firm

Source: adapted from Mueller (2003, p. 80)

Figure 1(a) illustrates the situation faced by young firms. As can be seen, new companies have investment opportunities with an optimum at I_Y^*, i.e. the level of investment consistent with the point where the marginal rate of return, mrr_Y, equals the weighted average cost of capital, $WACC_Y$. Now, as is also shown in the figure, in order to exploit these investment opportunities young firms require more funds than the cash flows, CF_Y, they can generate internally from operations. Consequently, new firms need to tap outside sources of capital at a relatively high cost, $WACC_Y$, in order to invest at the optimal level. According to lifecycle theory this higher cost of capital is due to "the different opportunities for raising external capital generally faced by new firms" compared to the corresponding opportunities faced by mature firms (Mueller, 2003, p. 81). Hence the figure implies that, because of this abundance profitable investment opportunities, young firms can be characterized as fast growing companies that pay little or no dividends, which need to have good relationships with outside investors (i.e. good corporate governance) in order to have access to outside funds and reduce their cost of capital as much as possible. It is important to notice that these firms depend on outside sources of finance if they are to undertake the investment opportunities open to them before the competition beats them to it.

On the other hand, Figure 1(b) depicts the situation confronted by mature firms. According to lifecycle theory, mature firms are characterized by having investment opportunities which at the optimal level I_M^* (the level of investment consistent with the point where the marginal rate of return, mrr_M, equals the weighted average cost of capital, $WACC_M$) require a smaller budget than the cash flows that the firm can generate internally from operations, CF_M. Importantly, this financial independence which mature firms enjoy *vis-à-vis* shareholders and other investors causes conflicts of interest. As suggested by Jensen (1986), why would growth maximizing managers, who enjoy the benefits from the growth of their firms such as higher salaries and more and better perks (Jensen and Meckling, 1976), pay out free cash flows to investors and thwart the growth of their firms? Wouldn't they rather overinvest and make their firm grow faster as shown in the figure by investing at the infra-marginal level I_M? The traditional answer in the finance literature is that if the management overinvests in this way, the market value of the firm would plunge and the firm would likely become the target of a hostile takeover (Manne, 1965; Mueller, 1969). The problem with this argument, however, is that while hostile takeovers may have been a problem for opportunistic managers in the 1980s, recent research suggests that for the last 30 years managers and their boards of directors have been deploying a large number of anti-takeover provisions which make the probability of success of a hostile takeover extremely small (Bebchuk, Cohen and Farrell, 2009; Cremers and Ferrell, 2014; Gompers, Ishii and Metrick, 2003). In other words, the threat of hostile takeovers has been effectively neutralized through the use of anti-takeover provisions, and for this reason firm lifecycle theory predicts that the managers of mature firms can and do overinvest in projects with a marginal rate of return which is lower than the corresponding weighted average cost of capital (i.e. these firms invest I_M, a level of investment at which mrr_M < $WACC_M$ in Figure 1(b)).

Now, most important for the purposes of the present paper, comparison between panels (a) and (b) in Figure 1 allows us to conjecture some important propositions regarding the behavior of the WACC over the lifecycle of the firm. In particular, this figure suggests that the WACC of mature firms should be lower than that of young firms for three reasons. The first is motivated by the illustrated increase in the size of cash flows from operations over the lifecycle of the firm. Clearly, since new firms are depicted as high-growth companies with relatively small cash flows from operations, which need external capital to exploit highly profitable investment opportunities, these companies will likely be willing and able to pay a high cost for the necessary capital. On the other hand, since mature firms are depicted as slow-growth companies with large cash flows from operations in excess of what is needed to invest optimally, that do not need to tap costly outside sources of capital, their WACC should be lower. Secondly, young firms usually have the most volatile cash flows. Since cash flow volatility increases the riskiness of the firm, high cash flow volatility should cause young firms to have a comparatively higher WACC. Conversely, since mature firms typically have more reliable and stable cash flows, this stability should reduce the riskiness and consequently the WACC of older firms. Thirdly, we put forward that there likely is a "reputation effect" that should cause the WACC of mature firms to be lower than that of young companies. Specifically, since the financial performance of mature firms is better known to investors they can rely on their past experience in dealing with the firm to assess the risk involved. In contrast, the future financial performance of new firms is more uncertain to investors. Therefore, the required return that investors demand from mature firms should be lower than that required from young corporations. Taken together, we expect that these three factors should more than compensate for the negative impact on the WACC of mature firms that results from the breakdown in corporate governance and the consequent overinvestment in negative net present value projects as illustrated in Figure 1(b). Consequently, we expect that the prediction of firm lifecycle theory, that the WACC of young firms will be higher than that of old firms, will hold.

We conclude this section by stating the testable propositions that will be investigated in the empirical sections of the paper. The main proposition, which follows directly from our discussion above, is that the WACC of the firm will tend to fall over its lifecycle. In addition to testing this qualitative proposition, we are interested in its quantitative impact. By how much does the WACC of young firms *vs.* that of mature companies differ? After how many years does it take for the WACC of a firm to fall below the average? We will examine these testable propositions in the empirical sections below.

3. ECONOMETRIC SPECIFICATION

We have seen that lifecycle theory predicts that the WACC is a function of firm age and other firm characteristics and that the first partial derivative of this function with respect to firm age is negative (that is, WACC declines as firms get older). However, the theory does not make any predictions regarding the sign of the higher derivatives. Consequently, we follow Mueller and Yun (1998, p. 359) and test the theory's predictions using the following five econometric specifications:

$$WACC_{it} = \alpha + \beta_1\, firmage_{it} + \gamma\; C_{it} + u_{1it} \qquad (1a)$$

$$WACC_{it} = \alpha + \beta_1 (1/\, firmage_{it}) + \gamma\; C_{it} + u_{2it} \qquad (1b)$$

$$WACC_{it} = \alpha + \beta_1\, firmage_{it} + \beta_2\, firmage_{it}^2 + \gamma\; C_{it} + u_{3it} \qquad (1c)$$

$$WACC_{it} = \alpha + \beta_1 (1/\, firmage_{it}) + \beta_2 (1/\, firmage_{it}^2) + \gamma\; C_{it} + u_{4it} \qquad (1d)$$

$$WACC_{it} = \alpha + \beta_1 \ln(firmage_{it}) + \gamma\; C_{it} + u_{5it} \qquad (1e)$$

Where *WACC* is the weighted average cost of capital, *firmage* is the age of the firm measured in years since its incorporation and *C* is a vector of controls and firm characteristics (put forward by lifecycle theory) likely to determine the WACC. As elements of *C* we include cash flows from operations normalized by total assets (*CF/totalassets*) and the three year volatility of these cash flows (*CFrisk*), the debt to value ratio *(D/(D+E))*, *Tobin's q*, the growth of sales of the firm over the previous year (*salesgrowth*), firm size measured as the natural logarithm of total assets (*lnfirmsize*), and finally industry and year dummy variables.[1] As mentioned above, firm lifecycle theory predicts that $\beta_1 < 0$ for specifications (1a), (1c) and (1e), and that $\beta_1 > 0$ for specifications (1b) and (1d), but makes no predictions regarding the sign of β_2.

The reason for including cash flows from operations over total assets and the three year volatility follows directly from our discussion on firm lifecycle theory above. In particular, the notion that young firms should have higher WACC because

[1] We describe our sources of data and how these variables are constructed in the appendix.

of their relatively small and volatile cash flows from operations, while mature firms should have lower WACC because of their greater and more stable cash flows. Since we will control for firm size as indicated above, we expect a negative relationship between WACC and *CF/totalassets,* as firms with larger and more stable cash flows should have a lower probability of default. Conversely, we expect a positive relationship between WACC and *CFrisk* because the more volatile the cash flows the higher will be the risk of the firm and the return required by investors.

In addition, we include the debt to value ratio to control for the fact that since debt is usually cheaper than equity, other things equal firms with a higher debt to value ratio should have a lower WACC. On the other hand, we include Tobin´s q and the growth of sales of the firm over the previous year to control for the differences investment opportunities that different firms have. With Tobin's q we aim to control for differences in potential investment opportunities, including growth through merger and acquisitions (Jovanovic and Rousseau, 2002). Conversely, with sales growth we expect to control for differences in the ability of firms to actually take advantage of those investment opportunities (La Porta, Lopez-de-Silanes, Schleifer and Vishny, 2002). Since the potential for rapid growth and actual rapid growth involves risk, we expect that the WACC will be positively related to both Tobin's q and sales growth.

Moreover, we include the natural logarithm of total assets to control for firm size. Since it has been argued that firm size reduces the probability of default (Hasan et al., 2015), we expect a negative correlation between firm size and the WACC. We also include industry dummy variables to control for the fact that project risk will likely vary depending on the industry.

Finally, our econometric specifications include time dummy variables to control for time fixed effects. The inclusion of time dummy variables follows recent work on the suitability of econometric methods in corporate finance. In particular, we follow the work of Petersen (2009) who shows that when using panel datasets in corporate finance a pooled regression with time dummy variables and standard errors clustered by firm can be used to avoid important pitfalls. In our econometric section bellow we will follow this approach.

4. DATA AND ECONOMETRIC RESULTS

4.1. Sample selection and description

Since the lifecycle theory of the firm was originally designed to explain economic and financial phenomena of the large modern corporation (Mueller, 1969, 1972, 2003), we need to collect data representative of this type of corporation in order to perform a valid and meaningful test of the theory. Thus, we collect a random sample of 586 U.S. firms listed in the S&P 500 and annual lists of corporations in the publications of Forbes, Fortune and Businessweek, with relevant data available both in the Datastream and Bloomberg databases. We then exclude banks, insurance and financial services companies since the accounting practices, risk and complexity of these companies is fundamentally different from those of most firms in the sample (Hasan et al., 2015). This reduces our final sample to 458 firms. Given that the Bloomberg data on the WACC starts in the year 2000, our period of study starts in that year and comprises the time period between 2000 and 2013.

Table 1 presents summary statistics for the main variables included in our econometric models. As can be seen, the companies in our sample present substantial variation in their WACC, age, cash flows, debt to value ratios and other variables of interest for testing our hypotheses.

Table 1. Summary statistics

This table presents summary statistics for the main variables included in our econometric models. *WACC* is the weighted average cost of capital as measured by Bloomberg (see the appendix). *Firmage* is firm age measured in years since the company's incorporation date. *lnfirmage* is the natural logarithm of firm age which is measured in years since the company's incorporation date. *CF/totalassets* is the ratio of the firm cash flows from operations during year *t* divided by total assets at the end of year *t*. *CFrisk* three year volatility of these cash flows calculated as the standard deviation of the firm's cash flows from operations from year *t-2* to *t*. *D/(D+E)* is the debt to value ratio calculated as the book value of firm debt to the book value of debt plus the market value of equity. *Tobin´s q* equals the market value of the firm at the end of year *t* divided by the book value of total assets at the end of year *t*. *salesgrowth* is the percentage change in the firm's total sales between the end of year *t-1* and the end of year *t*. *lnfirmsize* is the natural logarithm of the book value of the firm's total assets measured at the end of year *t* in thousands of constant 2010 U.S. dollars.

Variable	*N*	*Mean*	*Median*	*Std. Dev.*	*Min*	*Max*
WACC (%)	4785	8.9223	8.6840	2.3425	2.2820	25.7970
firmage	4785	71.4397	76.0000	31.7374	3.0000	165.0000
lnfirmage	4785	4.1401	4.3307	0.5560	1.0986	5.1059
CF/totalassets	4785	0.1061	0.0982	0.0657	-0.3643	0.5265
CFrisk	4785	0.0251	0.0167	0.0278	0.0001	0.3128
D/(D+E)	4785	0.2555	0.2199	0.1914	0.0000	0.9905
Tobin's q	4785	1.3906	1.0991	0.9805	0.0065	15.8453
salesgrowth	4785	0.0638	0.0550	0.2120	-0.8369	4.6195
lnfirmsize	4785	15.3940	15.3220	1.5251	11.0649	20.5767

Table 2 presents pairwise correlations between the empirical variables. Importantly, the WACC has a negative correlation with our measure of firm age (*lnfirmage*) which is significant at the 1% level. This suggests that, as predicted by firm lifecycle theory, the WACC tends to fall as firms mature. Moreover, the table shows that WACC has a negative correlation with the natural logarithm of cash flows from operations (*lnCF*) and a positive correlation with the volatility of cash flows from operations

(*CFrisk*), both of which are also significant at the 1% level. This finding suggests that, as predicted by lifecycle theory, the WACC falls as the size of the cash flows from operations increases and the volatility of the cash flows decreases. Conversely, note that there is a very strong correlation of 0.92 (significant at the 1% level) between our measures of firm size (*lnfirmsize*) and cash flow size (*lnCF*), so that if we include both variables in our regressions we would likely have collinearity problems. For this reason, instead of including *lnCF* in the econometric regressions we decided to include the firm's cash flows divided by total assets (*CF/totalassets*) instead. Although the pairwise correlation between WACC and *CF/totalassets* is positive and significant, we expect that once we control for firm size in the multiple regression equations the relationship between these two variables will be negative.

Table 2. Correlation matrix

This table presents the correlation matrix for the main variables included in our econometric models. Variable definitions are presented in Table 1 and their construction is discussed in the appendix, with the exception of *lnCF* which is the natural logarithm of cash flows from operations measured at the end of year *t* in thousands of constant 2010 U.S. dollars. ** and * indicate a statistically significant correlation at the 1% and 5% level respectively.

Variable	*WACC*	*lnfirmage*	*CF/total-assets*	*lnCF*	*CFrisk*	*D/(D+E)*	*Tobin's q*	*Sales-growth*	*Firm-size*
WACC	1.0000								
lnfirmage	-0.2245**	1.0000							
CF/totalassets	0.1529**	-0.1081**	1.0000						
lnCF	-0.1349**	0.1037**	0.3135**	1.0000					
CFrisk	0.2521**	-0.2126**	-0.0277	-0.1600**	1.0000				
D/(D+E)	-0.5296**	0.2314**	-0.4610**	-0.0356**	-0.1148**	1.0000			
Tobin's q	0.1649**	-0.2472**	0.5469**	0.1474**	0.1514**	-0.5263**	1.0000		
salesgrowth	0.0283*	-0.0472**	0.1566**	0.0813**	-0.0224	-0.0898**	0.1013**	1.0000	
lnfirmsize	-0.2253**	0.1714**	0.0574**	0.9244**	-0.2260**	0.1522**	-0.0226	0.0582**	1.0000

On the other hand Table 2 shows that, as can be obviously expected, the correlation between the WACC and the debt to value ratio *(D/(D+E))* is negative and significant at the 1% level, while the correlation between the debt to value ratio and our measure of firm age is positive and significant at the 1% level. These two correlations imply that as firms get older their debt to value ratio increases (firms use relatively more debt), and in turn, that this increase in the use of leverage is one of the mechanisms that cause the WACC to fall as firms mature.

Interestingly, Table 2 shows that the correlations between WACC and Tobin's q on the one hand and WACC and sales growth (*salesgrowth*) on the other are positive and significant, while the correlations between Tobin's q and firm age on the one hand and sales growth and firm age on the other are negative and significant. Viewed through the lens of firm lifecycle theory this suggests that young firms have abundant attractive investment opportunities and are growing fast compared to mature firms, but that they have relatively higher WACC as depicted in Figure 1. Finally, the correlation matrix shows a positive and significant correlation between our measures of firm age and firm size, and a negative and significant correlation between firm size and WACC. This implies that as firms mature they become larger and as a consequence of their larger size their WACC decreases. As it has been argued elsewhere in the literature, one plausible explanation for this observation is that firm size reduces the probability of default, and for this reason the WACC will tend to fall as firm size increases (Hasan et al., 2015).

4.2. Econometric results

Table 3 presents the results of our econometric analysis. In particular, columns 1a trough 1e present the estimates for the five specifications discussed in section 3. As can be seen all the specifications imply that WACC falls with firm age which is consistent with the predictions of firm lifecycle theory. On the other hand, we cannot choose among the five specifications in terms of fit to the data as all of them present a very similar adjusted R^2.

To facilitate our discussion on the trend of the WACC as firms get older, in Table 4 we present the WACCs for different firm ages implied by the estimates of Table 3. To obtain the values shown, we held all variables (other than WACC and firm age) at their mean values while varying firm age and taking note of the changes in the WACC. The last row of Table 4 presents the age of the firm (Age*) at which its estimated WACC equals the average WACC in the sample (i.e. 8.92%) as implied by the estimates in each econometric model. The five specifications indicate that for the average firm WACC falls below the average WACC in the sample at some point between the 52nd and 71st year after firm incorporation.

Among our econometric specifications, probably models 1b and 1d are the most plausible as they describe a gradual decline in the WACC until it reaches 8.69% and 8.66% in the limit respectively.[2] Conversely, 1a and 1e are somewhat implausible as their functional forms both imply a continual decline with the WACC eventually turning negative. Finally, model 1c implies that the average firm's WACC begins to rise after 133 years. One possible reason why this increase in the WACC could happen would be if the average firm enters a phase of general decline around this age. However, as the coefficient of age squared in model 1c is insignificant at any level of significance, we consider the implications of this model as somewhat implausible.

[2] This discussion follows Mueller and Yun (1998, 360) who use similar econometric specifications in another context, namely in the investigation of the behavior of rates of return over the lifecycle of the firm.

Table 3. Econometric results

This table presents the results of regressing *WACC* on firm age, other firm lifecycle characteristics likely to determine WACC, and control variables. Variable definitions are presented in Table 1 and their construction is discussed in the appendix. Note that we include year dummy variables to pick up movements in stock market values that are common to all firms, as well as industry dummy variables which we construct based on the FTSE/DJ Industry Classification Benchmark (ICB) super sector codes. ** and * indicate a statistically significant coefficient at the 1% and 5% level respectively. We report standard errors clustered by firm in parentheses.

Variable	*Predicted sign*	*1a*	*1b*	*1c*	*1d*	*1e*
Intercept	+	13.0758** (0.5550)	12.5448** (0.5739)	13.2956** (0.5787)	12.5018** (0.5802)	14.1536** (0.6060)
firmage	-	-0.0056** (0.0014)		-0.0126* (0.0056)		
1/firmage	+		12.1249** (2.3131)		14.0484** (3.9994)	
$firmage^2$	?			0.00005 (0.00004)		
$1/firmage^2$	?				-14.8501 (16.6617)	
lnfirmage	-					-0.3536** (0.0805)
CF/totalassets	-	-2.1391** (0.7816)	-1.8808* (0.7876)	-2.0736** (0.7889)	-1.8950* (0.7865)	-2.0282** (0.7815)
CFrisk	+	9.8223** (2.3424)	10.0411** (2.3372)	9.7712** (2.3264)	9.9773** (2.3339)	9.7993** (2.3272)
D/(D+E)	-	-5.0739** (0.3061)	-5.1088** (0.3060)	-5.0736** (0.3055)	-5.1068** (0.3059)	-5.0841** (0.3055)
Tobin's q	+	-0.1649** (0.0515)	-0.1969** (0.0509)	-0.1716** (0.0515)	-0.1954** (0.0506)	-0.1789** (0.0507)
salesgrowth	+	0.2952* (0.1304)	0.2799* (0.1256)	0.2882* (0.1287)	0.2806* (0.1256)	0.2862* (0.1281)
lnfirmsize	-	-0.1575** (0.0313)	-0.1593** (0.0310)	-0.1566** (0.0312)	-0.1584** (0.0311)	-0.1562** (0.0312)
Industry dummy variables?		yes	yes	yes	yes	yes
Time dummy variables?		yes	yes	yes	yes	yes
Adjusted R^2		0.5796	0.5806	0.5801	0.5806	0.5805
Number of observations		4785	4785	4785	4785	4785

Table 4. Calculated WACCs for different firm ages under each econometric model

This table presents calculated WACCs implied by the estimates in each econometric model. In these calculations we hold all variables, other than WACC and firm age, at their mean values. The last row presents the age of the firm, Age*, at which its estimated WACC equals the average WACC in the sample i.e. 8.92% as implied by the estimates in each econometric model.

Firm Age	*WACC (%)*				
	1a	*1b*	*1c*	*1d*	*1e*
1	9.31	20.81	9.52	7.86	10.39
5	9.29	11.11	9.47	10.88	9.82
10	9.26	9.90	9.41	9.92	9.57
20	9.21	9.30	9.30	9.33	9.33
30	9.15	9.09	9.20	9.11	9.18
40	9.10	8.99	9.10	9.00	9.08
50	9.04	8.93	9.02	8.94	9.00
60	8.99	8.89	8.95	8.89	8.94
70	8.93	8.86	8.88	8.86	8.88
80	8.87	8.84	8.83	8.84	8.84
90	8.82	8.82	8.78	8.82	8.80
100	8.76	8.81	8.75	8.80	8.76
110	8.71	8.80	8.72	8.79	8.72
120	8.65	8.79	8.70	8.78	8.69
130	8.60	8.78	8.69	8.77	8.67
140	8.54	8.78	8.70	8.76	8.64
150	8.49	8.77	8.71	8.75	8.61
160	8.43	8.77	8.73	8.75	8.59
Age*	71	52	64	53	63

Returning to Table 3, the results show a negative relationship between WACC and *CF/totalassets* which is significant at the 1% level or 5% level depending on the econometric specification. Our results imply, that if *CF/totalassets* increases by one standard deviation, the average firm's WACC falls by around 0.12 to 0.14 percentage points depending on the econometric model. On the other hand, the table shows a positive relationship between WACC and *CFrisk* which is significant at the 1% level. According to our results, if *CFrisk* increases by one standard deviation, then the WACC of the average firm increases by about 0.27 to 0.28 percentage points depending on the model. Thus, from these results we conclude that the impact of both variables on the WACC is also economically significant. In addition, since *CF/totalassets* and *CFrisk* control for the impact of cash flow size and volatility on the WACC, we conclude that the observed fall of the WACC as firm age increases (Table 4) is consistent with the existence of a "reputation effect" as hypothesized in section 2. Thus, our results are consistent with the lifecycle theory prediction that mature firms have a lower WACC due to their higher reputation and their relatively less volatile and bigger cash flows compared to new firms.

Turning to the control variables, all models in Table 3 show a negative relationship between WACC and the debt to value ratio (D/(D+E)), which is significant at the 1% level. This corroborates the widely held proposition that, since the cost of debt is typically lower than the cost of equity, as firms use proportionally more debt their WACC will fall. On the other hand, contrary to our expectations Table 3 shows a negative relationship between WACC and *Tobin's q* which is significant the 1% level for all specifications. This result suggests that, in the context of our study, Tobin's q is not functioning as a proxy for investment opportunities, rather *Tobin's q* represents a measure of firm valuation. In this sense, we conclude that the negative relationship between WACC and Tobin's q is due to the fact that, other things equal, as the firm's debt and equity are valued more highly by the market relative to their book value, the firm's cost of capital will be lower. In contrast, the table shows a positive relationship between WACC and *salesgrowth* which is significant at the 5% level. This corroborates our prediction that since actual rapid growth involves substantial risk, WACC should be positively related to *salesgrowth*. Finally, as expected we find a negative relationship between WACC and *lnfirmsize* which is significant at the 1% level. If firm size reduces the probability of default as has been hypothesized elsewhere (Hasan et al., 2015), then this lower risk of default should translate into a lower WACC.

4.3. Discussion of results

Firm lifecycle theory predicts that the WACC of the large modern corporation will tend to fall as companies become older. In this paper we present the first empirical test of this prediction and we find that the evidence is consistent with this expectation. In particular, we find that as firms mature the size of their cash flows from operations increases, while the volatility of said cash flows tends to decrease. These two facts reduce the overall riskiness of the firm and consequently the WACC falls with firm age. Interestingly, we find that even after controlling for cash flow size, cash flow volatility and other controls, WACC tends to fall with firm age. We hypothesize that this effect may be caused by a "reputation effect". That is, since investors should be less uncertain about the future performance of mature firms, they should require a lower risk premium from these companies which should result in a lower WACC.

Ex-post we find that the other variables employed in this work, which are found to have a significant impact on the WACC, are also related to firm age. For instance, the results show that firm size is positively correlated with firm age and that larger firms have a lower WACC. This suggests that another mechanism through which firm lifecycle dynamics impact the WACC is the increase in size that the firm usually experiments as it matures, since as has been argued elsewhere larger firms have a lower risk of default (Hassan et al., 2015). As another case in point, consider our result that younger firms tend to grow faster as measured by *salesgrowth* and that fast growing firms have a higher WACC. One likely explanation for this result is that the rapid growth generally experimented by young firms involves taking relatively higher risks and this higher risks increase the required return demanded by investors which in turn results in a higher WACC.

Interestingly, our results show that the debt to value ratio (*D/(D+E)*) is positively correlated with firm age. Since the WACC usually falls as the proportion of debt increases (as debt is typically less costly than equity), we conclude that one reason the WACC falls as firms mature is that lenders likely perceive mature firms as relatively less risky and are more willing to make debt capital available to these firms. Finally, we find that Tobin's q has a negative correlation with firm age. As discussed above, if we consider Tobin's q as a valuation proxy (as opposed to a proxy for investment opportunities) this result suggests that young firms are usually more highly valued by the market than mature firms. In turn, this higher valuation reduces the WACC for young firms.

5. CONCLUSION

This paper tests the prediction of firm lifecycle theory that the WACC of the firm will tend to fall as it becomes older. Since there is good *a priori* reason to expect that the opposite could happen, as previous research suggests that corporate governance deteriorates as companies mature (Mueller, 2003, pp. 80-81; Saravia and Saravia-Matus, 2016), the econometric tests performed in the present paper are important and necessary to clarify this question.

Our results show strong support for the proposition that the WACC of mature firms is significantly lower than that of new firms. If we take into account that previous work on firm investment performance finds that mature firms tend to destroy value by deliberately investing in projects with negative net present value (Mueller and Yun, 1998; Saravia, 2014), our evidence comes to shed new light on the magnitude of the corporate governance problems of mature firms. Putting these two facts together, that mature firms overinvest even though they have access to cheaper capital, we conclude that the corporate governance problems of mature firms are severer than what previous literature might suggest. Clearly, the implication is that mature firms are destroying value by undertaking projects with some of the lowest rates of return in the economy.

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APPENDIX A

This appendix explains how the empirical variables used in the paper were constructed as well as the sources of data employed. Our main sources of market and accounting data are Bloomberg and Datastream. We take the estimate of our main variable of interest, the WACC, from Bloomberg. Bloomberg calculates the WACC using the following equation:

$$WACC = KD\ (TD/V) + KP\ (P/V) + KE\ (E/V) \tag{A.1}$$

Where: *KD* is the *after-tax* weighted average cost of debt for the firm, *TD* is the total debt of the company, *KP* is the cost of preferred equity computed by dividing the sum paid in preferred dividends by the firm's preferred equity capital, *P* is the firm's preferred equity capital, *KE* is the cost of equity derived using the Capital Asset Pricing Model (CAPM), *E* is the firm's equity capital, and *V* is the company's total capital which is computed as the sum of total debt, preferred equity and equity capital ($V = TD + P + E$).

We construct our other key variable, firm age, by subtracting the year in which the firm was incorporated from the appropriate year in the panel dataset to obtain the number of years since the firm's incorporation. Our main data sources to construct this variable are the *Mergent Industrial Manual* which lists companies' dates of incorporation, and the date of incorporation Datastream datatype (wc18273).[3]

On the other hand, the variable *CF/totalassets* is constructed by dividing the firm's funds from operations (wc04201) by the book value of its total assets (wc02999) at the end of the company's fiscal year end. Furthermore, the volatility of firm cash flows, *CFrisk*, is computed as the standard deviation of the firm's funds from operations (wc04201) over a three year period, from the end of fiscal year *t-2* to *t*. The debt to value ratio *D/(D+E)* is constructed by dividing the firm's total debt (wc03255) over total debt plus the firm's market capitalization. Where, market capitalization is equal to the number of common shares outstanding (wc05301) times share price (P) at the date of the firm's fiscal year end.

Tobin's q is computed by dividing the market value of the firm over the book value of total assets (wc02999). Where, the market value of the firm is calculated by adding the firm's market capitalization (wc05301 x P) to its total debt (wc03255) and preferred stock (wc03451). The *salesgrowth* variable is computed by finding the yearly percentage change in the company's net sales (wc01001) from one fiscal year end to the next. Conversely, *lnfirmsize* is measured as the natural logarithm of total assets (wc02999) at the firm's fiscal year end, where the total assets are previously deflated by using the CPI (2010 = 1). The CPI data for the U.S.A were taken from the International Monetary Fund, World Economic Outlook Database, of April 2015. Finally, industry dummy variables were constructed based on the FTSE/DJ Industry Classification Benchmark super sector codes (icbssc) obtained from Datastream.

[3] Throughout this appendix Datastream datatypes are presented in parenthesis.