Facility Sustainment and Firm Value: A Case Study Based on Target Corporation

Author: Robert Beach

Abstract: This paper argues that increasing the level of facility sustainment (maintenance and repair) funding can increase firm value. Higher levels of facility sustainment funding reduce the list of maintenance and repair projects and maintain the liquidation value of the firm’s facilities. A condition is derived that establishes the minimum probability of financial distress required for firm value to increase as sustainment funding increases. This condition is tested with a case study based on the annual reports of a major retailer, Target Corporation. The results support the hypothesis. This holds even though adverse externalities that might occur from underfunding sustainment have not been considered.

Most firms are responsible for the operation of a number of buildings and other facilities. In managing these facilities, they must make decisions that can have a profound impact on human health and the natural environment. For example, consider Leadership in Energy and Environmental Design (LEED) standards for operation and maintenance of existing buildings. These standards apply to a number of operation and maintenance activities including occupant comfort, air quality, and waste management (U.S. Green Building Council, 2008). It is widely accepted that the decision to adopt LEED standards can reduce the harmful health and environmental effects from the operation of these facilities.

This paper looks at another important facility management decision: how much to fund facility sustainment. This decision can also significantly impact health and the environment yet receives little attention in the sustainability and corporate finance literature. As it is used here, facility sustainment refers to the yearly cost of maintaining a facility in good working order over its expected lifespan. Funding facility sustainment at 100% maximizes the value and usefulness of the facility. Underfunding facility sustainment not only leads to a growing backlog of maintenance and repair projects but can also result in catastrophic failures that lead to severe health and environmental consequences. For example, the 2005 explosion at the British Petroleum refinery in Texas City, Texas resulted in the death of fifteen people and pollution of the surrounding neighborhood. This incident was largely attributed to the inadequate maintenance of production facilities (Lyall, 2010). As another example, sources of Legionnaires’ disease, a very serious pulmonary illness, include large central air-conditioning systems that have been inadequately maintained. Despite its potential health and environmental consequences, many firms and organizations routinely underfund facility sustainment.
Facility Sustainment and Firm Value

sustainment since the costs of doing so will be deferred to an unknown point in the future. A recent assessment of the facility sustainment backlog at a major U.S. university was $620 million (Carlson, 2008). Many experts would agree that this is probably the typical case rather than the exception.

The hypothesis of this paper is that under certain conditions increasing sustainment funding can increase firm value. In many cases, the liquidation value of facilities that have been adequately maintained will be higher than otherwise and outweigh the additional expense of higher sustainment funding. The model developed here is based on a tradeoff theory of capital structure that takes into account the probability of financial distress and incorporates the facility degradation process that occurs when sustainment is underfunded. It represents the initial effort in the literature to model the impact of the level of sustainment funding on firm value. It contributes both to the literature on the tradeoff model of capital structure along the lines proposed by Damodaran (2006) and to the literature on sustainment funding and facility condition as discussed in Choi, Jondrow, Taylor, and Weis (1994) and Ottoman, Nixon, and Lofgren (1999a, 1999b).

Using a case study based on the financial reports of a major retailer, Target Corporation, it is shown that this hypothesis holds in two different versions of the model. The first is referred to as the finite valuation period model and is based on an expected value model of financial distress similar to that described in Damodaran (2006). A condition is derived for the probability of financial distress that must be met for firm value to increase as sustainment funding is increased. It is shown that for the parameters of the case study, this condition is met. Within the framework of this model, firm value is also calculated at Target’s historical level of sustainment, 51.7%, and at the recommended level of sustainment, 100%. The results support the hypothesis that firm value can increase as sustainment funding increases. The second model is a Monte Carlo simulation. Again Target’s historical funding level of 51.7% and the recommended funding level at 100% are considered. The Monte Carlo simulation also supports the hypothesis that firm value can increase as sustainment funding is increased.

A Model of Facility Sustainment and Firm Value

A version of the backlog projection model is used to model facility sustainment in this paper. The backlog projection model predicts the future backlog of maintenance and repair given expected funding. It requires estimates of sustainment cost factors, a method of measuring facility condition, a model of the facility degradation process, and estimates of degradation rates for different types of facilities.

Sustainment cost factors for facilities found on a typical military installation have been developed by Neely and Neathammer (1991) of the Army’s Civil Engineering Research Laboratory. These cost factors are updated annually and are also available from commercial sources such as the R.S. Means Company or Whitestone Research, both of which publish an annual update of facility
sustainment cost factors for commercial and residential facilities. The sustainment cost factors for retail stores used in the case study below come from government sources.

A facility condition index (FCI) measures the condition of a given facility and whether it meets the standard for the primary use of that facility. Ottoman, Nixon, and Lofgren (1999a, 1999b) summarize the various approaches to facility condition measures used by academic, government, and commercial planners.


Backlog projection models also require a degradation rate. The degradation rate for the retail stores considered in the case study come from studies conducted by the author and others (Beach, Carson, and Keating, 1998; and Beach, 2004).

Backlog Projection Model

The backlog projection model discussed above defines the relationship between funding and facility condition. It can be expressed as:

\[
C_t = (1 + \rho)C_{t-1} + S_t - F_t, \quad (1)
\]

where \(C_t\) is the cost of facility deficiencies (the backlog of maintenance and repair projects) at the end of year \(t\), \(\rho\) is the degradation rate, \(S_t\) is the required yearly sustainment to maintain the facility in good operating condition, and \(F_t\) is the level of sustainment funding for year \(t\). (The year subscripts are retained for \(S_t\) and \(F_t\) even though in the case study discussed below both are taken as constant.)

This equation can also be expressed as:

\[
C_t = (1 + \rho)C_{t-1} + (1 - \alpha)S_t, \quad (2)
\]

where \(\alpha\) is the percentage of sustainment funded. That is: \(F_t = \alpha S_t\).

The firm’s sustainment requirement, \(S_t\), for a given type of facility is computed using the following equation:

\[
S_t = TSF_t \cdot SCF, \quad (3)
\]
where $S_t$ is the firm’s sustainment requirements for year $t$, $TSF_t$ is the total square footage of that type of facility in year $t$, and $SCF$ is the sustainment cost factor based on the industry standard for a given type of facility.

**Finite Valuation Period Model**

The finite valuation period model estimates the expected firm value over a finite number of future years. The estimate of firm value is similar to the approach described in Damodaran (2006). This approach assumes there is a positive probability of financial distress and that expected firm value over the valuation period is made up of a going concern component and a financial distress component. This is expressed in the following equation:

\[
V_F = V_{GC} + V_{FD},
\]

where $V_F$, $V_{GC}$, and $V_{FD}$ represent the expected value of the firm, the expected value of the going concern component, and the expected value of the financial distress component, respectively.

The going concern value is based on the present value of the free cash flow of the firm over the valuation period. Free cash flow is estimated using the following equation:

\[
FCF = ebit(1 - t_c) + dep - (capex + \Delta nwc),
\]

where $FCF$ is free cash flow, $ebit$ is earnings before interest and taxes, $t_c$ is the corporate tax rate, $capex$ is the yearly capital expenditures, $dep$ is the current year depreciation, and $\Delta nwc$ is the yearly change in net working capital.

The expected going concern value of the firm is estimated by calculating the present value of the free cash flow of the firm over the valuation period times the annual probability that the firm will not experience financial distress. That is:

\[
V_{GC} = (1 - \pi) \sum_{h=1}^{H} \frac{FCF}{(1 + WACC)^h},
\]

where $FCF$ is the yearly free cash flow of the firm as defined in Equation 5, $H$ is the valuation period, $\pi$ is the annual probability of financial distress, and $WACC$ is the weighted average cost of capital based on the weighted average of the firm’s cost of debt and cost of equity.
By separating out sustainment cost expenses, the going concern value can be expressed in a more convenient form as:

\[ V_{GC} = (1 - \pi) \sum_{h=1}^{H} \frac{FCF_{adj} - \alpha S_h (1 - t_e)}{(1 + WACC)^h}, \]  

(7)

where \( FCF_{adj} \) is the free cash flow before subtracting out sustainment expenses.

The financial distress value is estimated as the expected liquidation value of the firm’s facilities.\(^1\) For liquidation value, we use the plant replacement value (PRV) of the facility adjusted for expected degradation based on the level of sustainment funding. PRV represents the cost of building a similar facility on the current site. It does not include site preparation or the value of the land. In the absence of fire sale effects, the adjusted PRV value represents a conservative estimate of the liquidation value since the market value could easily be much higher.\(^2\) The financial distress value can be expressed as:

\[ V_{FD} = \pi \sum_{h=1}^{H} \frac{PRV - \sum_{j=1}^{h} (1 + \rho)^j S_j (1 - \alpha)}{(1 + WACC)^h}, \]  

(8)

where all variables are as defined above.

Given Equations 3–8, the model of firm value can be expressed as:

\[ V_F = (1 - \pi) \sum_{h=1}^{H} \frac{FCF_{adj} - \alpha S_h (1 - t_e)}{(1 + WACC)^h} \]

\[ + \pi \sum_{h=1}^{H} \frac{PRV - \sum_{j=1}^{h} (1 + \rho)^j S_j (1 - \alpha)}{(1 + WACC)^h}, \]  

(9)

where \( V_F \) represents the expected value of the firm given sustainment funding at \( \alpha \)% and with an annual probability of financial distress of \( \pi \). Equation 9 states that expected firm value is the discounted sum of the expected cash flows for each year in the valuation period.

**The Critical Value of Financial Distress**

Taking the first derivative of Equation 9 with respect to the percent of sustainment funded, \( \alpha \), the following expression is derived:
It follows for this to be positive the following must hold:

\[
\pi \sum_{h=1}^{H} \frac{(1 + \rho)^{j-1}}{(1 + WACC)^h} > (1 - \pi)(1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + WACC)^h} .
\]

Solving Equation 11 for \( \pi \), the annual probability of financial distress, the following condition is derived.

**Condition 1.** Firm value increases as sustainment funding increases if the annual probability of financial distress is greater than the critical value, \( \pi_c \), described by:

\[
\pi_c = \left[ (1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + WACC)^h} \right] \left[ \sum_{h=1}^{H} \frac{(1 + \rho)^{j-1}}{(1 + WACC)^h} + (1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + WACC)^h} \right] .
\]

The critical value of the probability of financial distress, \( \pi_c \), can be interpreted as a measure of the likelihood that an increase in sustainment funding, \( \alpha \), will increase firm value. That is, as \( \pi_c \) decreases, the likelihood that an increase in \( \alpha \) will increase firm value will go up for any given valuation period.

The critical value of the probability of financial distress depends on the weighted average cost of capital, \( WACC \), the degradation rate, \( \rho \), and the valuation period, \( H \). The three propositions below determine the response of the critical value of \( \pi \) to changes in these three parameters.

**Proposition 1.** For a valuation period, \( H > 1 \), the response of the critical value of \( \pi \) to a change in the degradation rate, \( \rho \), is negative.

**Proposition 2.** For a valuation period, \( H > 1 \), the response of the critical value of \( \pi \) to a change in the weighted average cost of capital, \( WACC \), is positive.
Proposition 3. As the valuation period, $H$, becomes longer, the critical value of $\pi$ decreases.

The proofs of the three propositions can be found in Appendix A. Propositions 1 and 2 are consistent with the intuition that anything that reduces the liquidation value of the firm’s facilities will increase the critical value of $\pi$; and anything that increases the liquidation value of the firm’s facilities will decrease the critical value of $\pi$.

In the case of the degradation rate, the greater the degradation rate, the faster facilities degrade and the greater the potential gain if sustainment funding is increased. Hence the critical value of $\pi$ goes down as the degradation rate goes up.

In the case of the weighted average cost of capital, the greater the weighted average cost of capital, the more free cash flow and the liquidation value of the firm’s facility are discounted. At first glance, the impact of increasing the weighted average cost of capital is ambiguous. However, the liquidation value occurs when the firm experiences financial distress at the end of the valuation period and hence gets discounted the most. Proposition 2 confirms that this effect dominates and the critical value of $\pi$ goes up as the weighted average cost of capital increases.

Proposition 3 shows that it must be the case that as the valuation period becomes longer, the cumulative effect of the degradation process becomes greater and the critical value of $\pi$ decreases.

Case Study

The case study estimates the parameters of the finite valuation period model for a specific example: a major retail firm, Target Corporation. This firm was chosen because of the major retailers considered it was the only one that specifically stated its maintenance and repair costs in its annual reports. Data from the firm’s annual reports from 1993 through 2007, available on its website, is the basis for the analysis. Since the primary focus here is the firm’s facility sustainment funding, the analysis is simplified by assuming the firm’s property, plant, and equipment is represented by its retail stores. The loss of generality is minimized in this case since retail stores represent 95% of the firm’s facilities and 85% of the firm’s property, plant, and equipment.

This data is used to estimate the following parameters of the model:

- $TSF =$ Total square footage of the retail floor space;
- $\pi =$ Annual probability of financial distress;
- $\alpha =$ Historic level of sustainment funding of the firm as a percentage of requirements;
- $FCF =$ Free cash flow of the firm;
- $R_D =$ Cost of debt for the firm;
- $R_E =$ Cost of equity for the firm;
- $WACC =$ The firm’s weighted average cost of capital; and
- $t_c =$ The firm’s corporate tax rate.
Exhibit 1 | Case Study Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Square Feet (1,000 SF)</td>
<td>TSF</td>
<td>207,945</td>
</tr>
<tr>
<td>Probability of Financial Distress (%)</td>
<td>( \pi )</td>
<td>4.00</td>
</tr>
<tr>
<td>Sustainment Funding %</td>
<td>( \alpha )</td>
<td>51.70</td>
</tr>
<tr>
<td>Free Cash Flow ($million)</td>
<td>FCF</td>
<td>1,162.70</td>
</tr>
<tr>
<td>Cost of Debt (%)</td>
<td>( R_d )</td>
<td>5.55</td>
</tr>
<tr>
<td>Cost of Equity (%)</td>
<td>( R_e )</td>
<td>9.39</td>
</tr>
<tr>
<td>Weighted Average Cost of Capital (%)</td>
<td>WACC</td>
<td>7.64</td>
</tr>
<tr>
<td>Corporate Tax Rate (%)</td>
<td>( t_c )</td>
<td>37.80</td>
</tr>
</tbody>
</table>

Note: Parameters based on annual report data of Target Corporation for 1993–2007.

Exhibit 2 | Cost Factors and the Degradation Rate

<table>
<thead>
<tr>
<th>Cost Factor</th>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainment Cost Factor</td>
<td>SCF</td>
<td>$3.34/SF</td>
</tr>
<tr>
<td>New Construction</td>
<td>NCF</td>
<td>$92.21/SF</td>
</tr>
<tr>
<td>Degradation Rate</td>
<td>( \rho )</td>
<td>8.57%</td>
</tr>
</tbody>
</table>

Note: Cost factors and the degradation rate apply to retail stores for 2007, based on industry and DOD sources.

In addition to these parameters, standard cost factors and a degradation rate for retail stores are required. The cost factors for retail stores used here come from commercial and government sources. The degradation rate for retail stores comes from studies conducted by myself and others as cited above. For retail stores the following cost factors are required:

\[ SCF = \text{Sustainment cost factor per square foot}; \]
\[ NCF = \text{New construction cost factor per square foot}; \] and
\[ \rho = \text{Degradation rate expressed as a percent}. \]

Estimating the annual probability of financial distress is central to the analysis and is explained in the following section. The procedure for estimating the other parameters is discussed in Appendix B.

The parameter values for the case study are summarized in Exhibit 1. The cost factors and degradation rate values are listed in Exhibit 2.
Estimating the Probability of Financial Distress

Assuming a constant probability of financial distress over time, the market price of the firm’s bonds can be used to estimate the probability of financial distress, \( \pi \). That is, by adjusting the coupon and principal payments by the annual probability of financial distress, the bond price can be expressed in terms of certainty equivalent cash flows and discounted with the risk-free interest rate. Given bond prices for the firm’s outstanding debt, this means the probability of financial distress can be estimated using the following equation:

\[
\text{Bond Price} = \sum_{t=1}^{N} \frac{\text{coupon} \cdot (1 - \pi)^t}{(1 - r_f)^t} + \frac{\text{facevalue} \cdot (1 - \pi)^N}{(1 + r_f)^N}, \tag{13}
\]

where \( \pi \) represents the probability of financial distress and \( r_f \) is an appropriate risk-free interest rate.

Using the firm’s 10-year-to-maturity bonds, the above equation was solved for each bond issue and a weighted average computed for the value of the probability of financial distress. This method yields an estimated value for \( \pi \) of 4.0%.

Firm Value in the Finite Valuation Period Model

Testing Condition One

Using the values of \( \pi, \rho \), and WACC estimated for the case study, Condition 1 is tested. Critical values of \( \pi \) are calculated for 5-, 10-, 15-, 20-, 25-, and 30-year valuation periods. Consistent with Proposition 3, the longer the valuation period, the smaller the critical value required for an increase in sustainment funding to increase firm value. It is clear from Exhibit 3 that between years 20 and 25, the firm’s probability of financial distress of 4% will exceed the critical value and firm value will increase as sustainment funding increases.

Exhibit 3 also displays the critical values when the weighted average cost of capital is increased by 25% over the base case. Given Proposition 2, we would expect the critical value of \( \pi \) to go up relative to the case study. The last column displays the critical value when the degradation rate is increased by 25% over the case study. Given Proposition 1, we would expect the critical value of \( \pi \) to go down relative to the case study.

Comparing Firm Value: Historical Funding and 100% Funding

Using the model expressed in Equation 9, firm value is calculated for valuation periods of 5, 10, 15, 20, 25, and 30 years for the case where sustainment is funded at 51.7% (the firm’s historical rate) and 100%. The percentage change in firm value is calculated in the last column. These results are displayed in Exhibit 4.
Exhibit 3 | Comparison of the Critical Values of $\pi$ for Various Valuation Periods

<table>
<thead>
<tr>
<th>Valuation Period</th>
<th>Critical $\pi$ (Base Case)</th>
<th>Critical $\pi$ (WACC = 9.55%)</th>
<th>Critical $\pi$ ($\rho = 10.71%$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Years</td>
<td>16.3%</td>
<td>16.5%</td>
<td>16.0%</td>
</tr>
<tr>
<td>10 Years</td>
<td>8.9%</td>
<td>9.2%</td>
<td>8.5%</td>
</tr>
<tr>
<td>15 Years</td>
<td>5.9%</td>
<td>6.2%</td>
<td>5.4%</td>
</tr>
<tr>
<td>20 Years</td>
<td>4.2%</td>
<td>4.6%</td>
<td>3.8%</td>
</tr>
<tr>
<td>25 Years</td>
<td>3.2%</td>
<td>3.6%</td>
<td>2.8%</td>
</tr>
<tr>
<td>30 Years</td>
<td>2.5%</td>
<td>3.0%</td>
<td>2.1%</td>
</tr>
</tbody>
</table>

Notes: The table compares the critical values of $\pi$ for valuation periods of 5, 10, 15, 20, 25, and 30 years to the base case: probability of financial distress ($\pi$) = 4.0%; weighted average cost of capital (WACC) = 7.64%; and degradation rate ($\rho$) = 8.57%.

Exhibit 4 | Firm Value based on the Case Study Parameters and Cost Factors with a 4% Annual Probability of Financial Distress

<table>
<thead>
<tr>
<th>Valuation Period</th>
<th>Critical $\pi$ (%)</th>
<th>Firm Value at 51.7%</th>
<th>Firm Value at 100%</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Years</td>
<td>16.3%</td>
<td>7,418.660</td>
<td>6,783.498</td>
<td>-8.57%</td>
</tr>
<tr>
<td>10 Years</td>
<td>8.9%</td>
<td>12,269.947</td>
<td>11,477.954</td>
<td>-6.45%</td>
</tr>
<tr>
<td>15 Years</td>
<td>5.9%</td>
<td>15,332.082</td>
<td>14,726.708</td>
<td>-3.95%</td>
</tr>
<tr>
<td>20 Years</td>
<td>4.2%</td>
<td>17,143.079</td>
<td>16,974.978</td>
<td>-0.98%</td>
</tr>
<tr>
<td>25 Years</td>
<td>3.2%</td>
<td>18,074.694</td>
<td>18,530.871</td>
<td>2.52%</td>
</tr>
<tr>
<td>30 Years</td>
<td>2.5%</td>
<td>18,383.604</td>
<td>19,607.613</td>
<td>6.66%</td>
</tr>
</tbody>
</table>

Notes: Firm value based on the case study parameters and cost factors with the annual probability of financial distress, $\pi$, equal to 4.0%. The results are for 5-, 10-, 15-, 20-, 25-, and 30-year valuation periods. Firm value is in millions of dollars.

In Exhibit 5, the parameters are the same as in the case study except the probability of financial distress is assumed to be 5% instead of 4%. This exhibit illustrates that for a higher probability of financial distress, it takes a shorter valuation period before an increase in sustainment funding will increase firm value.

Monte Carlo Simulation

As an alternative approach, a Monte Carlo simulation is developed to calculate the impact of a change in sustainment funding on firm value. The simulation is
based on the probability of financial distress. Random numbers are generated based on this probability and used to determine a given realization. Using the Monte Carlo simulation, realizations in which the financial distress occurs in the first year can be considered with realizations in which financial distress occurs in a distant future year. The average of firm value for all of the realizations can then be used to estimate firm value.

Using the parameters estimated above for the case study, the Monte Carlo simulation is run for the following: (1) sustainment funded at the firm’s historical rate of 51.7% of requirements; and (2) sustainment funded at 100% of requirements.

The Monte Carlo simulations yield the following results. At 51.7% sustainment, firm value is calculated as $14,348.517 million. At 100% sustainment, firm value is calculated as $14,460.825 million. Firm value increases by 0.78% if sustainment is funded at 100%, which supports the hypothesis that fully funding sustainment can increase firm value.

**Sensitivity Analysis**

To test the robustness of this result, sensitivity analysis is performed by changing the values of the annual probability of financial distress, \( \pi \); the firm’s weighted average cost of capital, \( WACC \); and the degradation rate, \( \rho \).

The results of the sensitivity analysis are displayed in Exhibit 6. Changes in the parameters \( WACC \), \( \pi \), and \( \rho \) are calculated. Each parameter is increased by 25% and then decreased by 25%. The sensitivity analysis indicates that firm value goes up for an increase in \( \pi \) or \( \rho \), and for a decrease in \( WACC \). Firm value decreases for a decrease in \( \pi \) or \( \rho \), and for an increase in \( WACC \).
Exhibit 6 | Monte Carlo Simulation Sensitivity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parameter Value</th>
<th>Firm Value at 51.7%</th>
<th>Firm Value at 100%</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^+$</td>
<td>5.00%</td>
<td>$14,412,740$</td>
<td>$14,765,400$</td>
<td>2.44%</td>
</tr>
<tr>
<td>$\pi^-$</td>
<td>3.00%</td>
<td>$14,351,300$</td>
<td>$14,104,720$</td>
<td>-1.72%</td>
</tr>
<tr>
<td>$\rho^+$</td>
<td>10.71%</td>
<td>$14,183,760$</td>
<td>$14,460,825$</td>
<td>1.95%</td>
</tr>
<tr>
<td>$\rho^-$</td>
<td>6.43%</td>
<td>$14,525,876$</td>
<td>$14,457,311$</td>
<td>-0.48%</td>
</tr>
<tr>
<td>WACC$^+$</td>
<td>9.55%</td>
<td>$12,548,714$</td>
<td>$12,418,367$</td>
<td>-1.04%</td>
</tr>
<tr>
<td>WACC$^-$</td>
<td>5.73%</td>
<td>$16,762,781$</td>
<td>$17,294,136$</td>
<td>3.17%</td>
</tr>
</tbody>
</table>

Notes: Sensitivity of the Monte Carlo simulation to changes in the probability of financial distress ($\pi$), the degradation rate ($\rho$), and weighted average cost of capital (WACC). Increasing $\pi$ and $\rho$, or decreasing WACC results in an increase in firm value. Decreasing $\pi$ and $\rho$, or increasing WACC results in a decrease in firm value. Firm value is in millions of dollars.

These results are consistent with Propositions 1 and 2 above. Recall that Proposition 1 states that as the degradation rate increases, the critical value of $\pi$ decreases. This means for any given probability of financial distress, it is more likely that an increase in sustainment funding will result in an increase in firm value. Proposition 2 says that as the weighted average cost of capital increases, the critical value of $\pi$ increases. For any given probability of financial distress, it is less likely that an increase in sustainment funding will result in an increase in firm value.

Conclusion

This paper represents the initial effort to relate the literature on sustainment funding and facility degradation to firm value. It argues that the level of facility sustainment can be a significant factor in determining firm value for the major retailer considered in the case study. Higher levels of sustainment funding reduce the list of maintenance and repair projects and maintain the value of the firm’s facilities. Through the degradation process and the effect of the degradation rate, funding at lower levels of sustainment increases the rate of deterioration and accelerates the decrease in the liquidation value of its assets.

The analysis supports the conclusion that, at least for some firms, an increase in sustainment funding can result in an increase in firm value. In the finite valuation period model and the Monte Carlo simulation this is shown to be the true for the major retailer in the case study. Based on the Monte Carlo simulation, gain in firm value from fully funding sustainment in the case study is modest at 0.78%. This is due primarily to the low probability of financial distress of 4%. However, the Monte Carlo sensitivity analysis shows that at a slightly higher probability of
financial distress of 5%, the gain is more substantial at 2.44%. For firms facing more serious financial problems, the probability of financial distress could be much higher. Using the same method represented by Equation 13, Damodaran (2006) estimated that shortly before its bankruptcy proceedings, Global Crossing’s probability of financial distress was 13.53%.

Whether these results hold for another firm depends on the firm’s weighted average cost of capital, the firm’s annual probability of financial distress, and the degradation rates required for the firm’s facilities. If other major retailers have the same capital structure as the firm in the case study, it is quite likely that the results of this paper also apply.

The increase in firm value here is due to the increase in the liquidation value of the firm’s retail stores. The additional maintenance and repair expense of funding sustainment at 100% has been taken into account, but other factors that could have a positive impact on free cash flow and the going-concern value of the firm have not. For example, better maintained stores could have a positive impact on employee morale and productivity, as well as customer satisfaction. Both of these factors would increase firm value even more when sustainment is funded at 100%.

It is interesting to consider these results from the perspective of the firm’s stakeholders. The increase in firm value comes about from preserving the liquidation value of the firm’s assets. Because of the additional maintenance and repair expenses incurred, the cost of this is a reduction in the ongoing operations value of the firm since its free cash flow is reduced. For this reason, CEOs and shareholders may find fully funding sustainment is undesirable. Indeed, Graham, Harvey, and Rajgopal’s (2005) survey found that 78% of CEOs would sacrifice long-term value for short-term earnings gains. However, since it preserves the liquidation value of the firm’s assets, debt holders could find fully funding sustainment to be in their best interest. Since typically it is upper management and shareholders that have the final say as to the level of sustainment funding, this suggests that it is in the interest of the firm’s debt holders to include covenants regarding the level of sustainment funding when the corporation issues debt.

These results occur despite the fact that issues of pollution, health threats, and other adverse externalities that might occur from underfunding facility sustainment have not been taken into consideration.

Within the context of facility sustainment, this paper illustrates a potentially fruitful approach to considering issues related to green facilities and sustainability. By looking beyond free cash flow, it is clear that many firm decisions that have environmental or social consequences also impact the financial value of the firm. When these effects can be quantified, a clearer financial picture emerges as to their true benefits and costs.

Appendix A
Proofs of Propositions

Proposition 1. For a valuation period, $H > 1$, the response of the critical value of $\pi$ to a change in the degradation rate, $\rho$, is negative. That is:
Proof

From Equation 12:

\[
\frac{\partial \pi_c}{\partial \rho} = \left\{ - \left[ (1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + WACC)^h} \right] \right\} \left\{ (1 - t_c) \sum_{j=1}^{H} \frac{(j - 1)(1 + \rho)^{-j}}{(1 + WACC)^h} \right\} \left\{ \sum_{j=1}^{H} \frac{(1 + \rho)^{j-1}}{(1 + WACC)^h} + (1 - t_c) \sum_{h=1}^{H} \frac{1}{(1 + WACC)^h} \right\}^2 < 0. \tag{A1}
\]

First, note that since there are no negative terms in the denominator, it must be positive. By inspection, if \(H = 1\), the numerator equals zero. For \(H > 1\), both of the numerator terms in brackets are positive, and, since these are multiplied by \(-1\), the numerator must be negative.

**Proposition 2.** For a valuation period, \(H > 1\), the response of the critical value of \(\pi\) to a change in the weighted average cost of capital, WACC, is positive. That is:
Proof

From Equation 12, and simplifying:

\[
\frac{\partial \pi_c}{\partial \text{WACC}} = \left[ -\left( \frac{\sum_{h=1}^{H} (1 + \rho)^{j-1}}{(1 + \text{WACC})^{h+1}} \right) \frac{\sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h}}{\sum_{h=1}^{H} (1 + \text{WACC})^h} \right] + \left[ \frac{\sum_{j=1}^{H} (1 + \rho)^{j-1}}{(1 + \text{WACC})^{h+1}} \frac{\sum_{j=1}^{H} \frac{1}{(1 + \text{WACC})^j}}{\sum_{j=1}^{H} (1 + \text{WACC})^j} \right] \div \left\{ \frac{\sum_{h=1}^{H} (1 + \rho)^{j-1}}{(1 + \text{WACC})^{h+1}} \frac{\sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h}}{\sum_{h=1}^{H} (1 + \text{WACC})^h} \right\}^2 \cdot \frac{1}{(1 - t_c)} \right\}. \quad \text{(A4)}
\]
To simplify the notation let:

$$Z_h = \sum_{j=1}^{h} (1 + \rho)^{j-1}. \quad (A5)$$

Equation A5 has the property that if \( k > h \), then \( Z_k > Z_h \).

First, note that since there are no negative terms in the denominator, it must be positive. Thus, if the numerator is positive, then Proposition 2 must hold. That is, if:

$$- \left[ \sum_{h=1}^{H} \frac{Z_h}{(1 + \text{WACC})^h} \right] \left[ \sum_{h=1}^{H} \frac{h}{(1 + \text{WACC})^h} \right] + \left[ \sum_{h=1}^{H} \frac{hZ_h}{(1 + \text{WACC})^{h+1}} \right] \left[ \sum_{h=1}^{H} \frac{1}{(1 + \text{WACC})^h} \right] > 0. \quad (A6)$$

The proof is by induction. Letting \( H = 2 \) in Equation A6, we get the following terms:

$$- \left[ \frac{Z_1}{(1 + \text{WACC})^3} + \frac{Z_2}{(1 + \text{WACC})^4} + \frac{2Z_1}{(1 + \text{WACC})^4} \right] + \frac{2Z_2}{(1 + \text{WACC})^5} + \left[ \frac{Z_1}{(1 + \text{WACC})^3} + \frac{2Z_2}{(1 + \text{WACC})^4} + \frac{Z_1}{(1 + \text{WACC})^4} \right] + \frac{2Z_2}{(1 + \text{WACC})^5} = - \frac{Z_2 + 2Z_1}{(1 + \text{WACC})^4} + \frac{2Z_2 + Z_1}{(1 + \text{WACC})^5}. \quad (A7)$$

Since \( Z_2 > Z_1 \); Equation A6 must hold for \( H = 2 \).

Assume true for \( H = N \) and prove that the additional terms generated for \( H = N + 1 \) are zero or positive.

Expanding Equation A6 for the additional terms generated for \( H = N + 1 \):
The denominators for the terms in Equation A8 have exponents from $N + 3$ to $2N + 3$. That is,

$$\frac{1}{(1 + WACC)^{N+j}}, \quad (A9)$$

where $3 \leq j \leq N + 3$.

Numerator for the negative terms can be shown to be of the form:

$$(j - 2)Z_{N+1} + (N + 1)Z_{j-2}. \quad (A10)$$

Numerator for the positive terms can be shown to be of the form:

$$(j - 2)Z_{j-2} + (N + 1)Z_{N+1}. \quad (A11)$$

Since for $k > h$, $Z_k > Z_h$, it can be shown that for each $j$:

$$(j - 2)Z_{j-2} + (N + 1)Z_{N+1} > (j - 2)Z_{N+1} + (N + 1)Z_{j-2}. \quad (A12)$$

This means that for each term the positive numerators are greater than the negative numerators. The exceptions is when $j = N + 3$, in which case the positive numerator equals the negative numerator. Hence, the inequality in Equation A6 holds and the proposition is true.

**Proposition 3.** As the valuation period, $H$, becomes longer, the critical value of $\pi$ decreases. That is:
\[
\frac{\Delta \pi_c}{\Delta H} = \left\{ (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + \text{WACC})^h} \right\} \\
\div \left\{ \sum_{h=1}^{N+1} \frac{Z_h}{(1 + \text{WACC})^h} + (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + \text{WACC})^h} \right\} \\
- \left\{ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + \text{WACC})^h} \right\} \\
\div \left\{ \sum_{h=1}^{N} \frac{Z_h}{(1 + \text{WACC})^h} + (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + \text{WACC})^h} \right\} < 0.
\]

(A13)

Proof

It is assumed that \( H \) is a discrete variable. It is shown that the critical value of \( \pi \) for \( H = N + 1 \) is less than the critical value for \( H = N \). From Equation 12:

\[
\frac{\Delta \pi_c}{\Delta H} = \left\{ (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + \text{WACC})^h} \right\} \\
\div \left\{ \sum_{h=1}^{N+1} \frac{Z_h}{(1 + \text{WACC})^h} + (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + \text{WACC})^h} \right\} \\
- \left\{ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + \text{WACC})^h} \right\} \\
\div \left\{ \sum_{h=1}^{N} \frac{Z_h}{(1 + \text{WACC})^h} + (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + \text{WACC})^h} \right\}. \quad (A14)
\]

To simplify notation, let \( D_{N+1} \) represent the divisor of the first term in brackets and let \( D_N \) represent the divisor of the second term in brackets. Also, as above, let:

\[
Z_h = \sum_{j=1}^{h} (1 + \rho)^{j-1}, \quad (A15)
\]
and note that $Z_{h+1} > Z_h$.

Given this notation and finding a common denominator, the following expression is derived.

\[
\begin{align*}
\frac{\Delta \pi_c}{\Delta H} &= \left\{ \left[ (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + WACC)^h} \right] 
\frac{N}{1} 
\sum_{h=1}^{N} \frac{Z_h}{(1 + WACC)^h} 
+ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right. 
\left. - \left[ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right] \right\} 
\div \{D_{N+1}, D_N\}. 
\end{align*}
\]

(A16)

This simplifies to:

\[
\begin{align*}
\frac{\Delta \pi_c}{\Delta H} &= \left\{ \left[ (1 - t_c) \sum_{h=1}^{N-1} \frac{1}{(1 + WACC)^h} \right] \left[ \sum_{h=1}^{N} \frac{Z_h}{(1 + WACC)^h} \right] 
\frac{N}{1} 
\sum_{h=1}^{N+1} \frac{Z_h}{(1 + WACC)^h} 
+ (1 - t_c) \sum_{h=1}^{N+1} \frac{1}{(1 + WACC)^h} \right. 
\left. - \left[ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right] \left[ \sum_{h=1}^{N+1} \frac{Z_h}{(1 + WACC)^h} \right] \right\} 
\div \{D_{N+1}, D_N\}. 
\end{align*}
\]

(A17)

This can also be expressed as:

\[
\begin{align*}
\frac{\Delta \pi_c}{\Delta H} &= \left\{ \left[ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} + (1 - t_c) \frac{1}{(1 + WACC)^{N+1}} \right] 
\frac{N}{1} 
\sum_{h=1}^{N} \frac{Z_h}{(1 + WACC)^h} 
- \left[ (1 - t_c) \sum_{h=1}^{N} \frac{1}{(1 + WACC)^h} \right] \right\} 
\div \{D_{N+1}, D_N\}. 
\end{align*}
\]

(A18)

This further simplifies to:
\[
\frac{\Delta \pi_c}{\Delta H} = \left\{ \left[ (1 - t_c) \frac{1}{(1 + WACC)^{N+1}} \right] \left[ \sum_{h=1}^{N} \frac{Z_h}{(1 + WACC)^h} \right] \right.
\]
\[
- \left[ (1 - t_c) \frac{1}{(1 + WACC)^{N+1}} \right] \left[ \sum_{h=1}^{N} \frac{Z_{N+1}}{(1 + WACC)^h} \right] \}
\]
\[
\div \{ D_{N+1} \cdot D_N \} < 0. \quad \text{(A19)}
\]

Since \( Z_{N+1} \) is greater than any \( Z_h \), Proposition 3 must hold.

**Appendix B**

**Parameter Estimates**

**Total Square Footage**: The total square footage of the firm’s retail stores is based on the total square footage reported in the 2007 annual report. In 2007, total square footage (in thousands of square feet) was 207,945.

**Sustainment Requirement**: The sustainment requirement represents the amount that should be funded, based on industry standards, to maintain facilities in good working condition. It is the product of total square footage and the sustainment cost factor. That is:

\[
S_t = 207,495 \text{ SF} \cdot \$3.25/\text{SF} = \$675.821 \text{ million,} \quad \text{(B1)}
\]

where SF is in thousands of square feet.

**Sustainment Funding**: Sustainment funding is based on the firm’s expenditures for maintenance and repair of property, plant, and equipment. This type of information is not necessarily reported in a firm’s annual report. However, for the firm in the case study, maintenance and repair expenditures were reported for 2003–2007. Since 85% of property, plant, and equipment is retail stores, 85% of the maintenance and repair expenditure was applied to the retail stores. The average historical funding percentage was calculated based on the sustainment requirements for each of these years. The calculated historical funding is 51.7%.

**Free Cash Flow**: Free cash flow is estimated using the following equation:

\[
FCF = ebit \cdot (1 - t_c) + dep - (capex + \Delta nwc), \quad \text{(B2)}
\]

where \( ebit \) is earnings before interest and taxes, \( t_c \) is the corporate tax rate, \( capex \) is the yearly capital expenditures, \( dep \) is the current year depreciation, and \( \Delta nwc \) is the yearly change in net working capital.
Free cash flow was computed by averaging the above variables from the annual returns for 2003–2006. This was calculated as:

\[
FCF = 4560 \cdot (1.0 - 0.378) + 1,519 - (3,702 - 509) = 1,162,
\]

where all dollar amounts are in millions.

**Weighted Average Cost of Capital (WACC):** WACC is based on the weighted average of the cost of debt and the cost of equity. For the cost of debt, \( R_D \), the average yield to maturity of the firm’s 10-year bonds is used. This is calculated as \( R_D = 5.55\% \). For the cost of equity, \( R_E \), the CAPM model is used. Using the interest for the 10-year Treasury bond, \( r_f = 4.02\% \); beta = 0.70 (as reported on the Internet for 2007); \( E(R_m) = 11.69\% \) (based on the S&P 500 returns for 1928–2007). This is calculated as \( R_E = 9.39\% \). Debt and equity weights are in millions of dollars. Debt is based on the firm’s 2007 annual report and equity is based on the 2007 market capitalization. WACC is calculated as:

\[
WACC = \frac{17,090}{58,027} \cdot (5.55\%)(1 - .378) + \frac{40,937}{58,027} \cdot (9.39\%) = 7.64\%,
\]

where all dollar amounts are in millions.

**Endnotes**

1 I abstract from other costs of financial distress to focus on the impact of sustainment funding. The assumption here is these costs are the same for any given level of sustainment funding.

2 The argument against fire sales is along two lines: (1) they mostly occur when an industry or the overall economy is experiencing a downturn, or (2) when the assets are specialized and industry specific. Acharya, Bharath, and Srinivasan (2007) support the first argument and find no correlation in the second.

3 Damodaran (2006).

**References**


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Robert Beach, East Tennessee State University, Johnson City, TN 37614 or beachr@etsu.edu.