Stochastic Discounted Cash Flow Model for Pricing Analytics

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Abstract

This paper presents a stochastic discounted cash flow model designed to optimize pricing strategies and profitability assessment for a Waste Management Business company's municipal residential waste contract. In a competitive market, accurate profitability evaluation is essential for effective bidding and margin maintenance. To address this, we developed a reusable, Excel-based model that utilizes stochastic inputs to incorporate the variability of financial parameters over the contract lifecycle. The model captures revenue, cost factors, and EBITDA projections by applying a PERT distribution to stochastic variables, including fuel and labor costs, providing a realistic assessment range for each contract.

Sensitivity analysis within the model identified price per home (PPH) and seconds per pickup (SPP) as the most influential variables on profitability, guiding strategic adjustments for future contract bidding. Compared to the company's existing model, this stochastic approach achieved a 1.8% improvement in EBITDA margin, offering more refined insights into contract profitability. Moreover, the model's scalability enables its adaptation to additional contract types, such as commercial waste and recycling, thus broadening its applicability.

Ultimately, this stochastic discounted cash flow model equips Waste Management Business firms with a valuable tool for informed bidding. By balancing price, risk, volume, and profit through an adaptable, data-driven framework, the model enhances contract valuation strategies, improving long-term profitability and market competitiveness in dynamic Waste Management Business environments.

Index Terms: Stochastic Discounted Cash Flow, Waste Management Business, Pricing Analytics, Contract Profitability, Municipal Residential Waste Contracts, EBITDA, PERT Distribution, Sensitivity Analysis, Strategic Bidding, Financial Modeling, Revenue Optimization

I. INTRODUCTION

As one of the largest waste management companies in the United States, this organization provides an extensive range of services in waste collection, recycling, and disposal across residential, commercial, and industrial sectors. Each of these services includes municipal solid waste collection and recycling, which is particularly relevant for this project. Municipal solid waste contracts, often spanning 8 to 30 years, require a competitive bidding process and carry both high risk and high reward due to their long-term nature.

Before bidding on municipal contracts, the company must evaluate critical factors, including annual expenses, projected revenue, and anticipated profitability. Currently, this evaluation is conducted through a highly complex model, integrating hundreds of variables across multiple tabs, which requires significant expertise to generate accurate insights. However, as a leading player in the industry, the company must streamline and improve these evaluation tools to remain adaptable to market changes. The existing model, designed to generate static point estimates, falls short of capturing the inherent variability in influential factors like time to disposal, fuel costs, labor costs, and seconds per pickup. These variables' unpredictability underscores the need for a model that can account for both randomness and growth potential over time.

This study aims to address these limitations by developing a simplified stochastic model that accounts for uncertainties in key input variables. By moving from a static to a stochastic approach, the model will provide a distribution of profitability outcomes rather than a single point estimate. Such a model will enable the company to identify the most impactful variables on profitability, enhancing its understanding of the risks and rewards associated with each contract bid.

The proposed model consolidates essential parameters into a single, intuitive interface, allowing for a more dynamic view of potential profits and informing strategic decision-making. Initially focused on municipal residential waste collection contracts, this model is designed for scalability, with potential expansion to commercial waste collection and recycling contracts. This robust tool is intended to support comprehensive contract evaluation and facilitate optimized pricing strategies.

To ensure the model's accuracy, several assumptions have been incorporated, such as Department of Transportation regulations on truck operation hours, legal truck weight limits, and straight-line asset depreciation. Additionally, the cash flow analysis is discounted at a 6.5% rate, with projected market growth rates ranging from 1.5% to 3.5%. These parameters will empower the company to balance price, risk, volume, and profitability, enabling more confident and precise bidding on future contracts.

II. LITERATURE REVIEW

In the field of waste management, long-term contracts, particularly those related to municipal residential waste, are a significant revenue source and require detailed financial evaluation due to their inherent risk and extended duration, often ranging from 8 to 30 years. Literature on financial modeling in capital-intensive and long-term contract industries, such as waste management, consistently highlights the need for adaptable, stochastic models to better address the uncertainties in contract parameters (e.g., fuel and labor costs, inflation rates). Traditional deterministic models, though widely used, are often critiqued for their limitations in capturing variable volatility and for relying heavily on precise, fixed inputs. Studies have shown that static models may fail to provide a realistic assessment of profitability for contracts sensitive to price and cost fluctuations over time, suggesting that stochastic models are superior in dynamic environments.

In recent years, the stochastic discounted cash flow (DCF) model has gained traction as a method for handling financial projections under uncertain conditions. Unlike static DCF models, stochastic models utilize probabilistic distributions for inputs, enabling a broader range of potential outcomes and better risk assessment. Common approaches include Monte Carlo simulations and PERT distributions, which assign likelihoods to a range of input values, making them particularly suitable for parameters that may fluctuate widely over the life of a contract. Research suggests that stochastic DCF models not only offer a more accurate valuation but also aid in understanding the sensitivity of profitability to individual contract variables, thereby facilitating strategic decision-making in bidding and contract evaluation.

III. PROPOSED METHODOLOGY

To develop a robust financial evaluation tool, this study employs a stochastic discounted cash flow (DCF) approach to assess the long-term profitability of municipal residential waste contracts. The model is designed to overcome the limitations of Waste Management Inc.'s existing deterministic model by integrating randomness into critical input variables, offering a comprehensive view of potential contract outcomes.

The methodology follows a multi-step process:

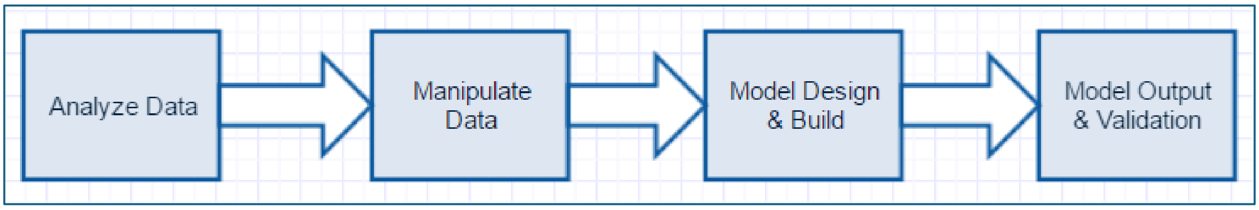

Figure 1: The process

Data Analysis: To streamline the analysis, worked with a smaller, focused subset of stochastic input variables that were identified as most influential on profitability outcomes. Each variable in this subset was defined by a minimum (MIN), maximum (MAX), and most likely (LIKELY) value, providing a range that accurately represented potential variability.

- The first step in data analysis involved examining each variable's range and characteristics. This examination enabled us to scale and adjust data appropriately, ensuring that each variable would reflect realistic values throughout the modeling process. Additionally, understanding the specific nature of each variable helped determine whether it should be treated as stochastic (random) or static (fixed). After discussion, it was concluded that only certain key variables demonstrated variability significant enough to affect profitability projections, while others remained relatively constant and could therefore be held as static inputs in the model.
- For the stochastic variables, a PERT distribution was selected due to its smooth, continuous nature. Unlike a standard triangular distribution, the PERT distribution centers around the mean while reducing the probability of extreme values in the skewed direction, making it well-suited for capturing the expected variability of each stochastic input. By implementing this approach, we could simulate realistic ranges for each input, enhancing the model's accuracy and better aligning with the actual conditions and risks associated with contract profitability.

Model Design and Parameter Selection:

The design phase centered on selecting key parameters to include in the model and categorizing them as either stochastic or static inputs:

- Stochastic Inputs: Variables expected to vary significantly over time were treated as stochastic inputs, such as fuel and labor costs. For these variables, a PERT distribution was chosen, as it captures a realistic range of values by defining minimum, maximum, and likely values based on historical data inputs.
- Static Inputs: Variables with known, fixed values (e.g., contract term, pickup frequency) were defined as static, as they are explicitly outlined in contract terms. This approach allowed for more accurate modeling by eliminating unnecessary variability.
- Stochastic Growth Rates: For stochastic variables prone to long-term inflation, such as labor costs, a growth rate was applied to adjust future values, reflecting the expected price drift over time. This adjustment provided a realistic projection of costs throughout the contract's duration.
- Proportional Fixed Expense Adjustments: To align the model with the full financial structure, certain expenses were set as fixed proportions of revenue (e.g., insurance at 3% of revenue) and labor expenses were increased by 38% to account for benefits. This adjustment ensured that the model's output was comparable to the existing deterministic model.

Model Formulation:

The financial model was developed in Microsoft Excel, leveraging the platform's calculation and simulation tools:

- Deterministic Model Development: An initial deterministic model was created to establish baseline values for three key operational parameters: the number of days a truck operates per week (Q_RD), the number of trucks purchased per period (Q_Tr_IN), and the number of daily trips each truck makes to disposal (N).

By using the likely values for each stochastic input, this model maximized the NPV within the constraints of weight limits and operational hours, which are crucial for regulatory compliance.

- Stochastic Simulation Model: With the deterministic model established, a stochastic simulation model was developed using Palisade's @Risk add-in for Excel. This simulation introduced variability into the deterministic baseline by iterating through random values for each stochastic input variable, generating a distribution of NPV outcomes rather than a single value. Multiple simulations were run to assess how variations in inputs would affect profitability and to provide a comprehensive view of potential outcomes.

VI. EVALUATION & CONCLUSION:

The new model's effectiveness was assessed by comparing its output with a sample contract analyzed using the existing deterministic model. This comparison focused on key financial metrics, including Net Present Value (NPV), Internal Rate of Return (IRR), and EBITDA. While initial comparisons centered on NPV, differences in scope between the two models led to focus primarily on EBITDA as a benchmark for validation. The deterministic Model includes a wider range of contracts and associated capital costs (such as commercial waste and recycling), which naturally results in higher expenditure figures. Consequently, NPV and IRR estimates from the new stochastic model were slightly elevated due to its narrower scope, limited to municipal residential contracts.

Used Palisade @Risk in Excel to simulate 20,000 iterations of the model, generating a distribution of EBITDA values. The simulation results indicated a mean EBITDA of approximately $4M, with a 90% confidence interval ranging from $4.045 million to $4.335 million.

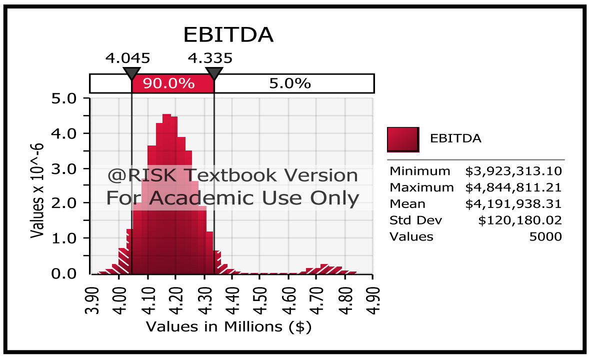

Figure 2: Distribution of EBITDA

Sensitivity analysis highlighted that key drivers of EBITDA were Seconds per Home (SPH) and Price per Home (PPH), underscoring their importance in profit optimization.

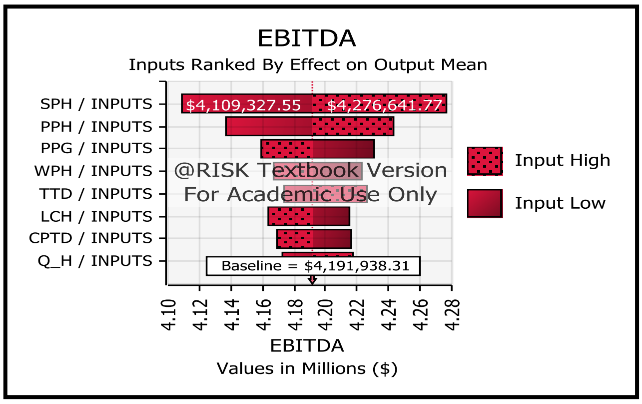

Figure 3: Sensitivity Analysis

Compared to the deterministic Model, the new stochastic model yielded a slightly higher mean Revenue/EBITDA percentage of 41.6%, in contrast to the existing Model's 39.8%. The distribution ranged from 31.4% to 52.3%, demonstrating close alignment with the existing Model's outcomes, albeit with minor variations due to the exclusion of additional contract types and related costs. These results confirmed that the new stochastic model provides an accurate profitability projection for municipal residential contracts.

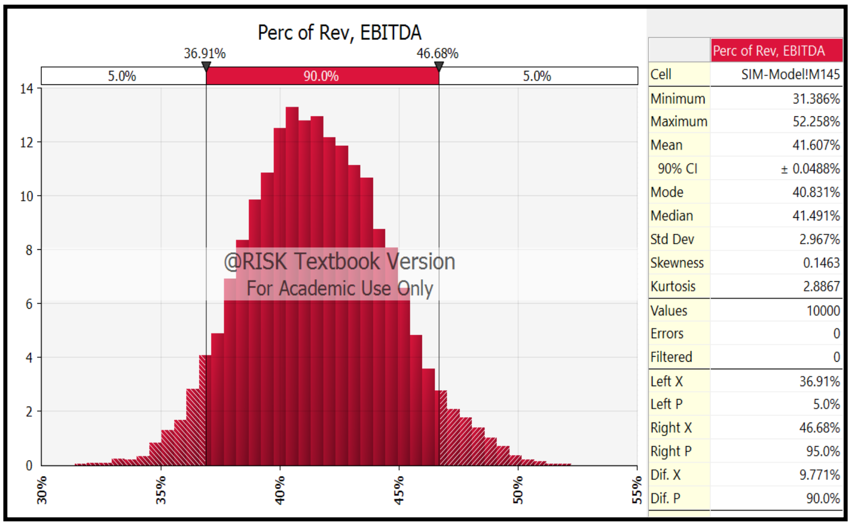

Figure 4: Revenue/EBITDA Percentage Distribution

In conclusion, the newly developed Stochastic Simulation Model offers a scalable, reusable tool for evaluating the profitability of multi-period residential waste contracts. It allows us to estimate optimal ranges for NPV, EBITDA, and IRR, giving insight into profit potential and sensitivity to key variables. The model's capability to perform sensitivity analysis through Tornado graphs enables us to identify variables that most significantly impact EBITDA, allowing strategic adjustments to maximize contract profitability.

Moreover, this model provides flexibility in selecting optimal distributions for input variables, enabling visualization of distribution curves over time. Advanced sensitivity analysis further enhances decision-making by illustrating the relationship between mean EBITDA and input percentiles. Additionally, it offers confidence intervals (e.g., 90% or 95%) for output ranges, helping us assess profitability stability.

With its scalable design, the model can be easily expanded to include commercial contracts and recycling services, potentially replacing the deterministic model. Adjustments for additional variables and historical data insights can improve the model's accuracy, making it an adaptable and valuable tool for future contract evaluations.

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