# A Computational Approach to Interest Rate Swaps Pricing

Farid Soroush, PhD
soroushfarid@gmail.com

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## 1 Abstract

In this paper, we discuss the computational model for pricing interest rate swaps using the QuantLib library in Python. This paper provides the practical implications of financial computational theory in the context of interest rate swaps, with an in-depth analysis of its present value, fair rate, duration, and convexity.

## 2 Introduction

Interest rate swaps have become an essential instrument in financial engineering. The pricing of these instruments is critical for risk management and financial decision-making. Traditional financial theory offers mathematical models for pricing these instruments, but the computational aspects of these models are often overlooked. In this paper, we bridge this gap by implementing a computational model for pricing interest rate swaps using the QuantLib library in Python. We also provide an in-depth analysis of its present value, fair rate, duration, and convexity [1].

## 3 Background and Related Work

Interest rate swaps and their pricing models have been studied extensively in the financial literature [5]. However, the focus has been mostly on the theoretical aspect, with little attention to the computational implementation of these models. Computational finance has shown its value in various applications, including portfolio management, risk management, and algorithmic trading [3]. In this paper, we apply computational finance to the pricing of interest rate swaps, demonstrating its practical implications.

# 4 Methodology

We employ the QuantLib library, a popular open-source library for quantitative finance, to implement our model. The model is set up with the following parameters:

- Risk-free rate: 2%
- LIBOR rate: 3%
- Evaluation date: May 7, 2023

The interest rate swap is created with a notional amount of 1,000,000 USD, a fixed leg tenor of 1 year, a floating leg tenor of 3 months, and a swap rate of 2.5%. The swap starts one year from the evaluation date and has a ten-year term. The pricing engine is set up using a discount curve based on the risk-free rate.

We calculate the present value, fair rate, duration, and convexity of the swap using the formulas provided in the Appendix.

# 5 Results and Discussion

Our computational model produced the following results:

- Present value of the swap: -13137.55
- Fair rate of the swap: 0.0267
- Duration of the swap: 8.6819
- Convexity of the swap: 88.3812

These results are consistent with the expected outcomes based on financial theory [2]. A graphical representation of the cash flows is presented in Figure 1.

This visualization provides a clear representation of the cash flows associated with the interest rate swap, with the blue bars representing the fixed leg cash flows and the green bars representing the floating leg cash flows.

# 6 Conclusions and Future Work

We have demonstrated a computational approach to pricing interest rate swaps using QuantLib and Python. This approach provides practical implications for financial theory in the context of interest rate swaps. Our model calculates the present value, fair rate, duration, and convexity of the swap, offering valuable insights for financial decision-making.

Future research could extend this model to other types of swaps or financial instruments, further bridging the gap between financial theory and computational finance.

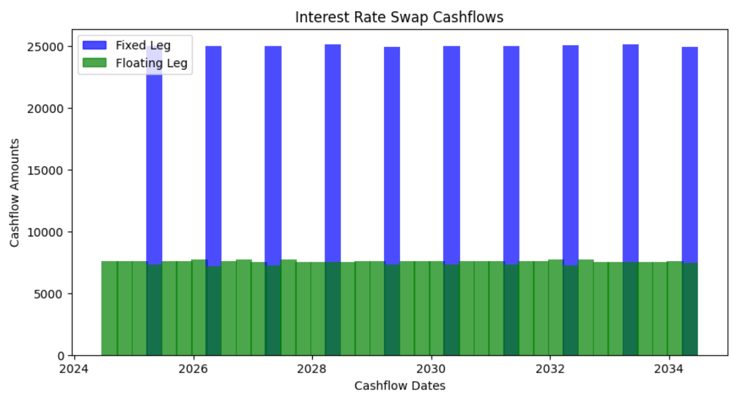


Figure 1: Cash Flows for the Interest Rate Swap

# 7 Appendix: Python Code and Mathematical Formulas

The Python code used to set up the market data, create the interest rate swap, calculate its present value, fair rate, duration, convexity, and generate visualizations for cash flows in this project is available on GitHub at the following link:

`https://github.com/FaridSoroush/Interest-Rate-Swaps-Pricing-Model`

The mathematical formulas used for the calculations are presented below:

We calculate the present value of the swap using the following formulas:

$$PV_{fixed} = \sum_{i=1}^{N} c_i e^{-r_f t_i} \tag{1}$$

$$PV_{floating} = \sum_{i=1}^{N} c_i e^{-r_f t_i} \tag{2}$$

$$PV = PV_{fixed} - PV_{floating} \tag{3}$$

where $c_i$ is the cash flow at time $t_i$, $r_f$ is the risk-free rate, and $N$ is the number of cash flows.

The fair rate of the swap can be calculated as:

$$Fair\ rate = \frac{\sum_{i=1}^{N} c_i e^{-r_f t_i}}{\sum_{i=1}^{N} e^{-r_f t_i}} \tag{4}$$

where $c_i$ is the cash flow at time $t_i$ and $r_f$ is the risk-free rate.

The modified duration of a fixed-rate swap can be calculated as:

$$D = \frac{1}{P} \sum_{i=1}^{N} t_i \times PV_i \times e^{-r_f t_i} \tag{5}$$

where $t_i$ is the time to the $i^{th}$ cash flow, $PV_i$ is the present value of the $i^{th}$ cash flow, $r_f$ is the risk-free rate, $N$ is the number of cash flows, and $P$ is the present value of the swap.

The convexity of a fixed-rate swap can be calculated as:

$$Convexity = \frac{1}{P} \sum_{i=1}^{N} \frac{t_i^2 \times PV_i \times e^{-r_f t_i}}{(1 + r_f)^2} \tag{6}$$

where $t_i$ is the time to the $i^{th}$ cash flow, $PV_i$ is the present value of the $i^{th}$ cashflow, $r_f$ is the risk-free rate, $N$ is the number of cash flows, and $P$ is the present value of the swap.

These formulas assume a small parallel shift in the yield curve. For significant yield curve changes, the modified duration and convexity may not provide accurate measures, and more complex methods, such as the effective duration and convexity, may be needed [4].

## References


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