AN INVESTIGATION INTO THE USE OF HEDGING FUEL FOR FCT

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1 Abstract

A model of the stochastic nature of diesel prices allows us to extract and evaluate accurate probabilities that will enable us to assess the cost of hedging against diesel price fluctuation. This will then let us evaluate how FCT could hedge fuel prices. We find that we can use our model to price the cost to hedge fuel and explain how this can be used to reduce the uncertainty of future costs, although it comes with setbacks due to the assumptions made and difficulty implementing them in practice.

2 Introduction

We know from the FCT Response to the DfI Budget 2023-24 Equality Impact Assessment that "Any cut or ending of the funding for rural community transport will bring about grotesquely profound painful disproportionate and adverse impacts on rural persons with a disability." This statement was the catalyst for this investigation and prodded the question of how using our mathematical ability could help secure or improve the budget for FCT, which could positively impact the lives of those affected by transport poverty. If we look at a company such as Ryanair, they can maintain low fairs even during significant jet fuel price increases. They can achieve this by hedging most of their fuel [1]. So, this investigation aimed to see if hedging could be used for FCT to improve their budget and have less uncertainty over costs.

Firstly, what is hedging? Hedging is taking a position to offset the risk of adverse price movements; in the case of FCT and Ryanair, the adverse price movement would be the cost of fuel going up, so to offset this risk Ryanair locks in a price for now for future delivery this is called a futures contract this ensures a fixed cost for fuel. However, this wouldn't work as FCT would have to store the diesel upon delivery, which would be too costly, however, we could enter into a financial contract that pays if the fuel price goes up. This would involve no physical fuel, but the payments would mitigate price rises, so we have chosen to investigate this.

Why would it benefit FCT to hedge fuel costs? The increase in the last 3 to 4 years has consumed the replacement cost for two new drivers for FCT. We saw that in 2022/23, the total expenditure for FCT on fuel rose to £80,00 due to the spike in retail diesel prices, which was an approximately 43% increase on the previous year. Due to the current global affairs, it isn't unthinkable that another shock event could occur once more, thus FCT is exposed to the risk of fuel prices rising this would mean more money would be spent on fuel and less on helping the people of Fermanagh.

Section 3 details the Geometric Brownian Motion model being used and where we got our data from. Section 4 details how these contracts operate and how our model approximates a known analytic solution for pricing protection. Section 5 discusses the assumptions and issues with the proposed solution and how it reduces uncertainty in fuel costs.

3 Model

The diesel price has been modeled Using a modified Geometric Brownian Motion model shown in Equation (1) where S_t has been adjusted to be risk neutral. GBM is a continuous time stochastic process in which the logarithm of a randomly varying quantity follows a Brownian motion with a drift [2].

$$S_t = S_0 \prod_{i=1}^{t/\Delta t} \exp\left(\left(\mu - \frac{\sigma^2}{2}\right)\Delta t + \sigma X_{\Delta t}\right) \tag{1}$$

$$X_{\Delta t} \sim \mathcal{N}(0,\ \sqrt{\Delta t}) \tag{2}$$

In simple terms Equations (1) & (2) state that future price of diesel s_t is being simulated using the following 5 factors:

1. The initial price at which the random walk starts from S_0 in this report will use S_0 as 140 pence.

2. The drift term μ is the log of the historical average change in diesel price in northern Ireland per week.

3. σ Is the log of the standard deviation of the change in diesel price in northern Ireland per week

4. t This is the time the model is being evaluated for in the future.

5. $X_{\Delta t}$ This is the stochastic portion of our equation. This is a normally distributed random variable with mean 0 and variance equal to the square root of the time elapsed . This is the portion responsible for the Brownian motion.

The reason for using GBM to model diesel prices is that it has been shown to be a good proxy for pricing financial instruments on similar commodities such as crude oil [3]. In addition, it has most certainly been the most influential model ever implemented in finance. Over the last 50 years, it was the basis for trillions of trades. If it serves as a good base for the biggest banks and insurance firms in the world, I believe it would suffice for this project.

All the data used for historical prices in this investigation was obtained from the Consumer Council of Northern Ireland fuel price checker, which allowed us to obtain average weekly fuel prices in Northern Ireland since 2020. I requested their data for Enniskillen fuel prices specifically in hopes that it would provide the most accurate model. Still, I was informed that "Unfortunately, the contract terms mean that we cannot share the granular fuel prices as an open resource. ". I believe that the open source data is accurate as the price deviation between the average in Northern Ireland and Fermanagh should not be significant.

Shown in Figure 1 is the simulation of 10 random walks using Equation (1). The price of diesel varies with no discernible pattern for each random walk. This is what we are looking for as we are not looking to predict diesel prices but to extract the probability that price rises could occur.

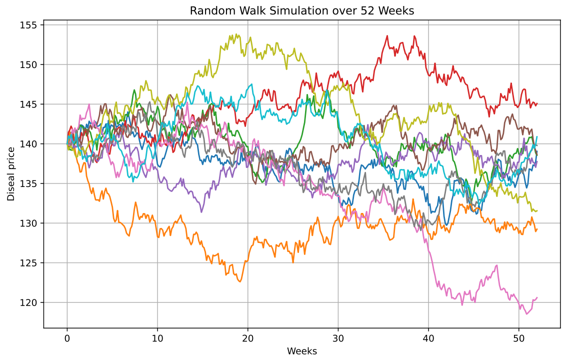

Figure 1: Simulation of 10 random walks of diesel price over 52 weeks using our GBM with Δt as 1/7 and S_0 as 140 pence with our x-axis representing weeks.

4 Proposal

The proposal is the use of a financial contract for FCT with a set action price, such that if diesel prices per liter rose above a given date, the difference would be paid back to FCT. This would mitigate any sudden large increase in fuel costs for FCT.

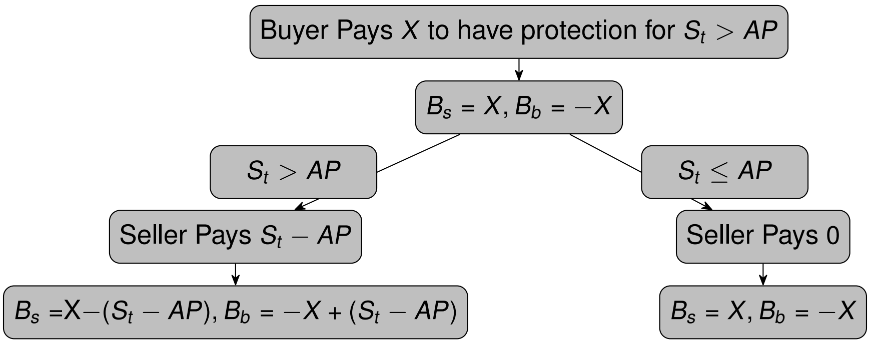

Figure 2: Flow diagram of the Payouts of a contract with action price AP for diesel price S_t, X is the cost for the buyer to buy protection for $S_t > AP$. B_s & B_b are the total amount Lost or gained by the seller and the buyer. FCT is the buyer as they are the party looking for protection.

The flow diagram shown in Figure 2 shows how the payout for each contract works given the two possible outcomes: if $S_t > AP$, then the buyer is paid $S_t - AP$ and if $S_t < AP$, then the buyer is paid nothing.

This could be applied to FCT in the following manner: We can estimate FCT uses a constant rate of fuel each week F litres, we would then buy F contracts per week, and if we are planning for a year, we would purchase 52 sets of F contracts which have a set action price AP. Then, each week, the diesel price would be evaluated if $S_t > AP$, we would get paid out $F(S_t - AP)$. As we bought F contracts for this week, the payout should be scaled proportionally to the amount of fuel used in a week.

To obtain the price of X we say that if we have a set AP for time t the fair price for the contract to the buyer is equal to the expected payout for the seller for that AP at time t. So, as an example, we ran our simulation of the random walk of diesel price 5000 times, which allowed us to estimate the expected payout from the seller at each time step (each day) given an AP of 143 pence, by calculating the probability that a random walk starting at S_0 which was 140 pence, was greater than 143 at each time step and then of the random walks greater than 143 pence at each time step what was the average value over 143 pence they were, which allowed us to calculate the expected payout at each time step for this particular contract, which allowed us to produce Figure 3. The blue line is the estimated expected payout from the seller. Plotted in black is the pricing of European call options using Black-Scholes plotted for strike price 143 pence. As we can see, our expected payout approximates Black-Scholes with our model being systematically higher this difference is caused by Black-Scholes more effectively accounting for discounting future cash flows than our model so by using Black-Scholes we have this improved benefit, so we now have a fair analytic solution to price these contracts. Black-Scholes was the first analytic solution to price financial derivatives' fair value, allowing Banks to control risk better. From now on, we will be using Black-Scholes to price the cost of contracts to allow for more accurate pricing.

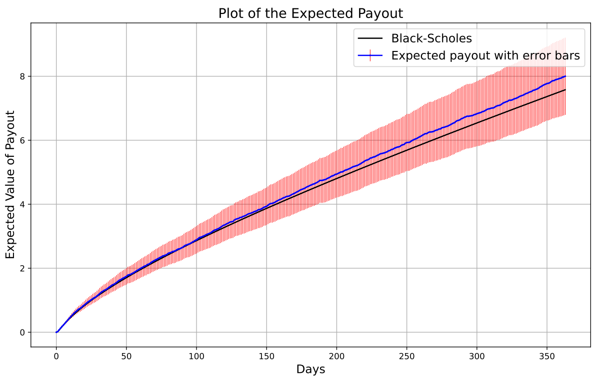

Figure 3: Shows the expected payout of the contract with an action price of 143 pence when it has started from an initial value of 140 pence and follows GBM with a sample size of 5000 simulations. Shown in black is the pricing of European call options using Black-Scholes plotted for an action price 143 pence. Our x-axis represents time in days

Shown in Figure 4, I have plotted the total cost to buy protection for a year priced using Black-Scholes, assuming FCT use 40000 litres of fuel a year at a constant rate and buy in weekly sets of contracts. As we can see, the further we buy into the future, the more expensive the contracts become, and the closer the action price is to the initial price, the more expensive contracts become. This should be intuitive as the further away a contract is purchased for the more likely the event that it reaches the set AP is to occur as the price has more time to move and the closer the AP is to our S_0 is more expensive as its more likely to reach a closer value. Using this FCT could tailor the AP and determine how far into the future they would like protection for, to their risk tolerance and budget.

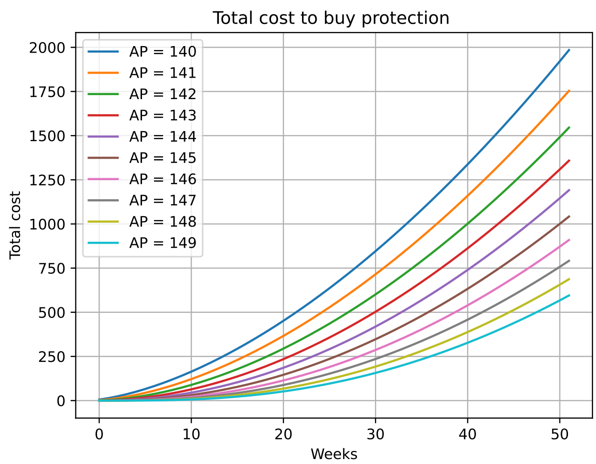

Figure 4: Plot of the total cost for protection for a given number of weeks and action price assuming FCT use 40000 litres of fuel a year at a constant rate. The price of diesel starts at 140 pence. Grid lines have been added for readability. With our time on the x-axis being in weeks.

5 Conclusions

So, could FCT use hedging with these contracts to reduce uncertainty about future fuel costs and improve budgeting? The answer is yes. See Figure 5. We can see that the variance of future costs using hedging is much lower than without which was done by simulating the total cost for fuel a company buying the estimated amount of fuel as FCT per day buying at the price that the simulation of the random walk of diesel dictates but one simulation deploys hedging meaning it pays a premium at the beginning but gets repaid difference if diesel price is above an AP of 142 pence and the other uses no hedging and taking the sample variance of the total cost of these simulations we could produce this figure, the reduction in variance for the hedged simulation means that we are reducing the uncertainty of future costs which is positive it would allow FCT to better budget fuel cost. This is also commonplace in large transport companies, so we know it can work in practice. We can also see from Figure 4 that using these contracts, the cost of buying a full year of protection is relatively small in comparison to the total cost of fuel.

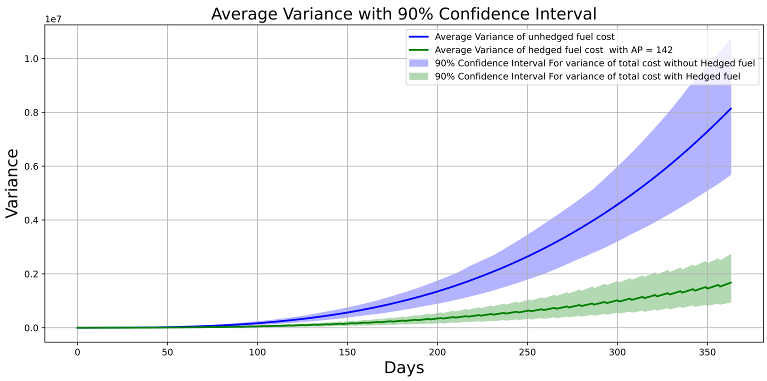

Figure 5: Shows the comparison between the estimated variance of total fuel costs between hedged with AP=142 pence in green and unhedged in blue with a 90% confidence interval. This was created by simulating 100 samples of 50 random walks of diesel price and assuming FCT used 40000 litres of fuel a year at a constant rate, buying equal fuel each day according to the price of each random walk we simulated a version with and without hedging deployed and then we took the variance of the sample of the cumulative total spent by both simulations each week allowing us to demonstrate the difference of variance of total fuel cost.

It has also been shown that financialization has helped charities reduce costs in the past when coming to foreign exchange such as the Brooke which is an animal welfare charity that used forward contracts to hedge against foreign exchange risks and allow it to access better interest rates [4]. This is widely used by charities which aim to work in emerging or unstable economies with exotic currencies where sudden inflation can rapidly devalue the funds available to them meaning they have less purchasing power to help those in need, thus by deploying a hedging strategy they aim to minimise this risk in fact there are companies dedicated to working with charities as well as banks on to minimise risks such as Charity FX which deploy foreign exchange hedging [5].

Translink also uses financial derivatives for its fuel usage it uses forward contracts they benefit by getting much cheaper fuel as these forward contracts are bought in bulk and also have a guaranteed price locked in. However, this leaves them open to the price dropping while they still must buy such large amounts at the same price which has stung them heavily in the past [6]. If FCT were to use this project idea it would not have this risk as they still buy fuel at market price so the most cost they can be out is known and that is the cost of the contract.

However, our work has two main issues: Possible errors in the cost of these contracts and the difficulty of implementing this in practice.

We may be underestimating the price of these contracts for several reasons. Firstly, we ignore the cost of evaluating these contracts to the selling party; someone would have to work to settle these, which would cost the selling party, which would be added to the protection price. Secondly, in our model, we assume constant variance in modern banking; companies devote billions to estimating the accurate variance of assets and how this variance evolves. They will add premiums to account for this. Our variance is very simple and may be underestimated, leading to the actual cost for these contracts to be greater . Also, we estimate that FCT uses 40,000 litres of fuel at a constant rate, which could vary greatly if minibuses break down, etc. and also account for FCT not operating on weekends in our simulation. However, I would be inclined to believe that this difference would be insignificant.

Secondly, we assume that we have a party to conduct these contracts. This may prove an impossible task. In practice, companies are offering this service, but they will be severely overcharging. It would have to be done with a party in a philanthropy way, where this party, instead of donating directly to FCT, would conduct the transaction with FCT, meaning they aren't technically donating. However, they would be providing a means to reduce costs for FCT. We also ignore the possibility of taxing this transaction as this may step outside of the tax exemptions under which the charity operates.

References

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[3] Nwafor, Chioma N.; Oyedele, Azeez A. - Simulation and Hedging Oil Price with Geometric Brownian Motion and Single-Step Binomial Price Model. https://researchonline.gcu.ac.uk/ws/portalfiles/portal/24776117/Simulation_of_Crude_Oil_Prices_EJBM_Vol.9_No.pdf (Accessed 20/10/2024)

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