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# Optimization-Based Fuel Surcharge Hedging

Daniel Connors
IBM Research, dconnors@us.ibm.com

Dan A. Iancu
IBM Research, dan.iancu@us.ibm.com

Leo Janus
IBM Integrated Supply Chain, lrjanus@us.ibm.com

Kaan Katircioglu
IBM Research, kaan@us.ibm.com

## 1. Introduction

The various economic stimuli and monetary easing policies introduced by central banks and governments in the aftermath of the global market crash of 2008, coupled with recent shocks in the commodity markets, ranging from supply constraints, all the way to political or weather related events (Kilman and Berry 2011, Denning 2011), have contributed to a spike in commodity prices, fueling fears and intense discussions on governmental, corporate and individual levels.

Certain companies are naturally more vulnerable than others to commodity price pressures. For instance, key players in the transportation industry, such as airlines and cargo carriers, are very sensitive to kerosene or diesel fuel prices, which often account for more than 80% of their cost structure. Companies in the food industry suffer not only from a large dependency on soft commodities (such as sugar, wheat, rice, corn or cocoa), but also receive additional exposure through third-party interactions (e.g., fuel surcharges applied by cargo companies). While a fraction of the increased production costs can be directly passed to the consumers (Glazer 2011), food companies have realized that the measure has limited use, and have increasingly begun adopting more elaborate practices, such as hedging (Wiggins 2008) or some form of vertical integration (e.g., Nestle is known to invest in farming cooperatives in China and India).

## 2. Model Description

In view of these realities, the current paper introduces a very simple and effective model for capturing some of the realistic constraints and decisions faced by companies seeking to establish a hedging practice. Our model has several salient features and assumptions, which we outline below.

- We focus on the problem faced by a company whose core business is non-financial, but which is directly exposed to the price of an underlying commodity. More precisely, we consider a manufacturer shipping finished goods at different locations world-wide, and faced with unknown transportation costs. To model the associated cost structure, we use an approximation that is very close to the exact surcharge scheme applied by large US and EU-based cargo carriers (e.g., UPS (UPS 2011), FedEx (FedEx 2011) and DHL), whereby direct surcharges tied to an underlying commodity index are directly applied to each pound of goods shipped on behalf of the manufacturer.
- We account for two major sources of uncertainty in the cost structure: the total transportation volumes (tied to actual sales volumes, and varying by time and region), and actual fuel prices, which influence the underlying index, and hence the exact surcharges applied by the cargo company.

- We assume that the manufacturer can purchase several types of derivatives, such as futures contracts and European call and put options with different expiration dates and strike prices (Hull 2005). We assume that all derivatives are based on the same underlying index as the fuel surcharges[1], and that the market for the instruments is liquid and large (in particular, the manufacturer's hedging practices do not influence the price of the underlying commodity - a reasonable assumption when dealing with an agricultural or technology company, and fuel as the commodity).
- We assume that the manufacturer has a particular budget available for hedging purposes. This is in keeping with other studies (Cobbs and Wolf 2004), which find that companies seldom hedge their full exposure, due to either accounting practices or executives' hesitance into launching a hedging practice (often viewed as not a core competency). We take the budget as a constraint, but discuss how its impact can be assessed analytically, as well as embedded as a decision variable.
- We limit attention to static hedging practices. In particular, we assume that all financial instruments are purchased in the first period, subject to the budget constraint. While there is evidence that dynamic hedging improves performance, e.g., by taking into account the seasonal pattern of particular commodities (Cobbs and Wolf 2004), our decision to opt for a static hedging is mainly driven by the fact that such a model has better chances of being adopted in practice (particularly at companies that are unwilling to establish active trading desks). We also remark that our underlying model can be extended to dynamic decision settings, by encapsulating simple adjustable hedging practices, without increasing the computational complexity of the formulation.
- Our model is flexible in the exact specification of the uncertain quantities. What is required are sample-paths of the relevant stochastic processes, which could be obtained from historical data, by black-box forecasting methods, or by Monte-Carlo simulation.
- In order to assess the risks in the cash-flows, we adopt the modern theory of coherent risk measures (Shapiro et al. 2009). While our present formulation involves Conditional Value-at-Risk (also known as Expected Shortfall), the model can be extended to capture a wider array of risk measures and preferences.

## 3. Outline of Contributions and Results

Our main contributions and results are as follows.

- We rigorously formulate the problem of finding an optimal (static) portfolio of financial instruments, in order to minimize the manufacturer's risk, subject to budget and investment constraints.
- We show an interesting connection between our approach and a robust formulation of the problem, where the commodity prices, the volumes and the prices of calls and puts are modeled using set-based descriptions (Ben-Tal et al. 2009), and the worst-case costs are minimized. This enables the use of a relevant duality result in order to simplify the analysis and gain insight into the problem structure.
- Using a Sample Average Approximation approach (Shapiro et al. 2009), we show that, for a large class of risk measures, the ensuing model is a tractable convex optimization problem (for the case of a CVaR measure, a linear program). This makes the approach amenable to high-performance software (ILOG 2010), and also (in view of the duality result mentioned previously) allows the use of sensitivity analysis to understand the impact of a particular change in a problem parameter.
- We conduct an extensive simulation study, using real surcharge rates and financial data on futures, calls and puts prices, as well as simulated shipping volume data. Our results (see Figure 1 for a representative example) show the potential benefit of performing static hedging, whereby a relatively small budget can protect against potentially very large losses. We also find that the hedging policy is more robust to model mis-specifications. Namely, for the cases when the planned contingency arises (e.g., an increase in prices is expected, and does actually arise - Figure 1 (d), (e) and (f)), the hedged policy

[1] This is usually an approximation. For instance, US air freight surcharges are computed in US dollars, with respect to kerosene-based indexes, and futures on kerosene are available for purchase only on the Tokyo stock exchange, in Japanese Yen. One could either purchase derivatives based on a different underlying asset (e.g., crude or heating oil), hence introducing *basis risk* (Hull 2005), or one could purchase instruments in Yen, hence introducing currency risk. We discuss how these risks can be accounted for, and how robustness can be built into the model.

provides large improvements in terms of both expected cost, as well as risk reduction. For cases when the planned contingency does *not* arise (Figure 1 (a), (b) and (c)), the hedged policy results in a slightly larger average cost, but nonetheless typically reduces the underlying variability / risk.

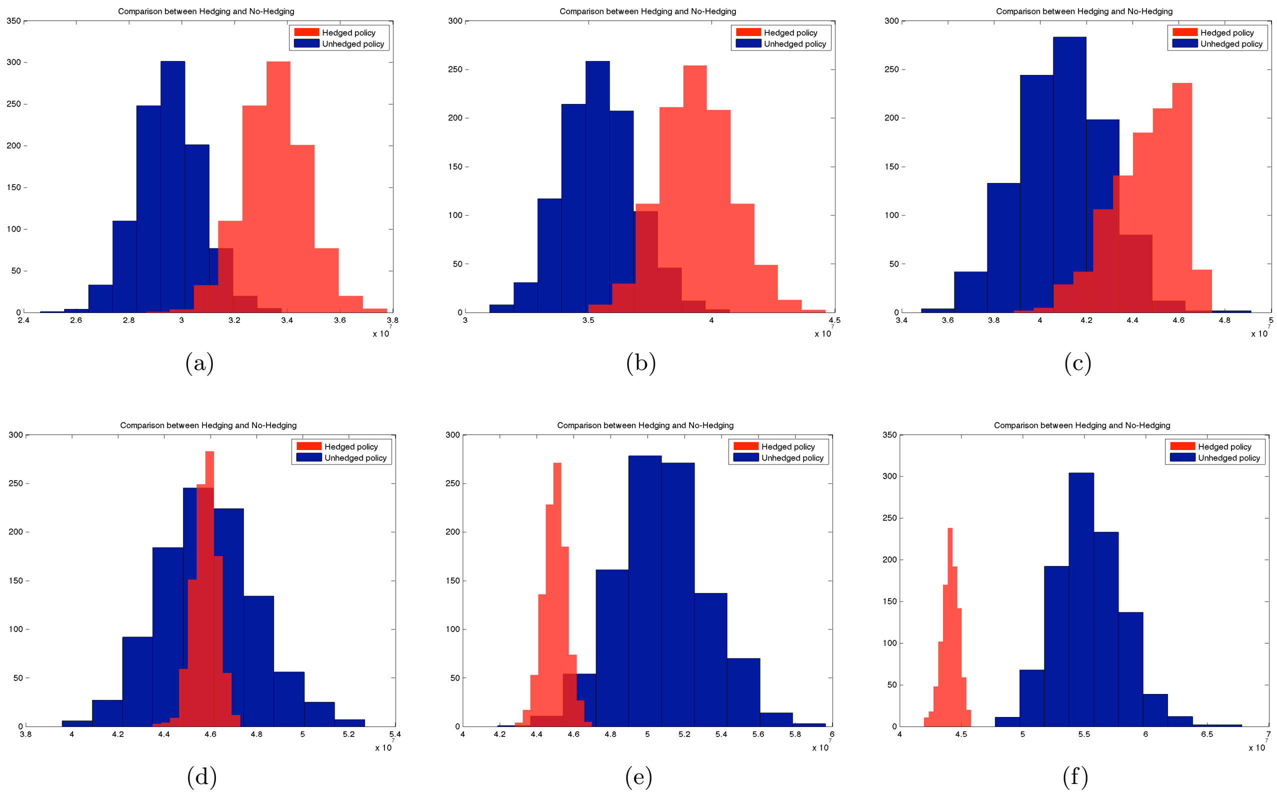


**Figure 1** **Comparison of Hedged (Red) and Unhedged (Blue) Policies. The planned for contingency differs from the realized situation. Namely, all models plan for a 30% average price increase, but the average realized price change is −50% (a), −30% (b), −10% (c), +10% (d), +30% (e) and +50% (f), respectively.**

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