Innovations in Risk Analytics

Risks & Hedging Techniques for Swing Contracts with Take-or-Pay, Make-up & Carry-Forward Features

John Breslin
Les Clewlow
Chris Strickland
Daniel van der Zee

Lacima Group

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The main features of swing contracts which make them difficult to value and risk manage are the constraints on the quantity of, for example, gas which can be taken. The main constraint is that in each gas year there is a minimum volume of gas (termed take-or-pay or minimum bill) for which the buyer will be charged at the defined contract price (which may depend on other market indices), at the end of the year (or penalty date), regardless of the actual quantity of gas taken. Typically, there is also a maximum annual quantity which can be taken.

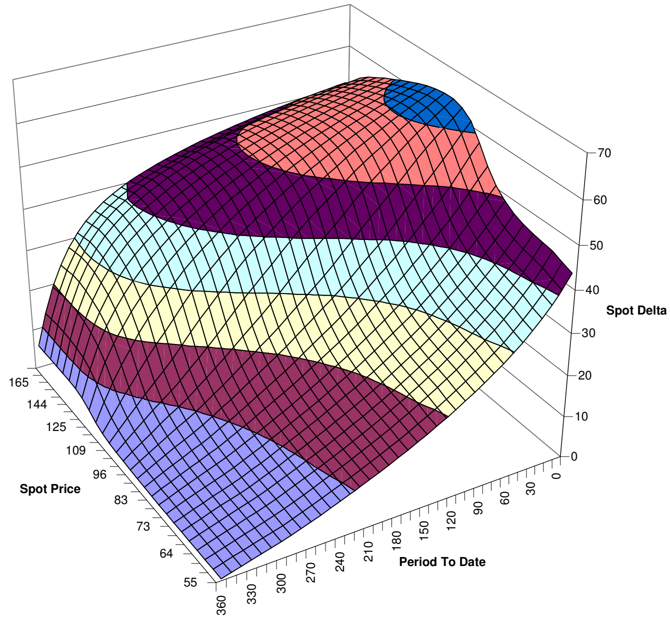
A seller of daily swing takes on an unhedged risk profile which is a complex mixture of a daily settled swap and a strip of daily call options. It is this nature of the volume uncertainty which gives swing contracts a risk profile which is difficult to manage. If the minimum bill is equal to the sum of the daily maxima then the swing contract has no flexibility for the buyer and is equivalent to a daily swap. For the seller this is the least risky position since there is no volume uncertainty and the contract can be effectively hedged in the forward market. As the minimum bill is reduced, below the sum of the daily maxima, the contract begins to take on a risk profile that is closer to that of a call strip. However, the difference is that the swing contract can sometimes behave like a swap and sometimes like a call strip depending on the spot price, contract price and the volume of gas already taken.

There are two ways we can analyse the risk of swing contracts; the delta surface and the cashflow and volume distributions[1].

Figure 1 shows examples of the spot delta of a 1 year take-or-pay swing contract with daily contract quantity (DCQ) = 1, minimum bill (MB) = 80%, annual maximum = 365, contract price = 100, and forward curve flat at 100 under a mean reverting model for the spot price.

Day 0 (0% into the year)

[1] We assume interest rates are zero to allow easier comparison of cashflow distributions at different time horizons.



Day 219 (60% into the year)

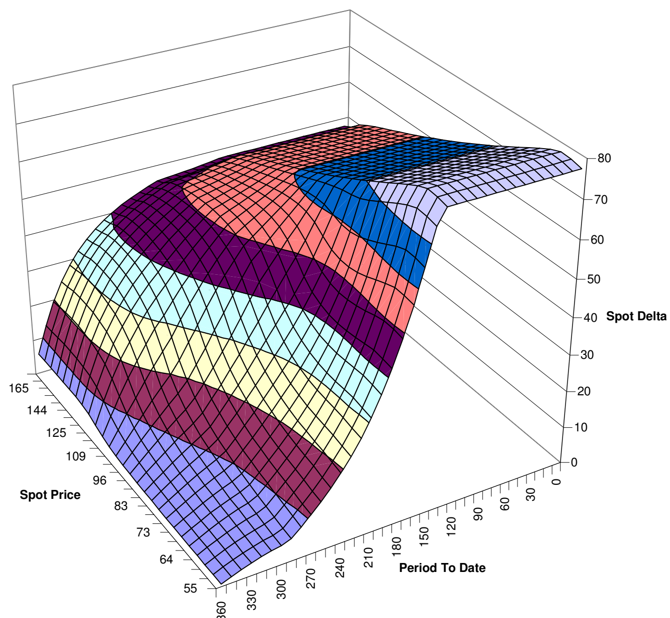


Figure 1: Example Spot Delta Surfaces

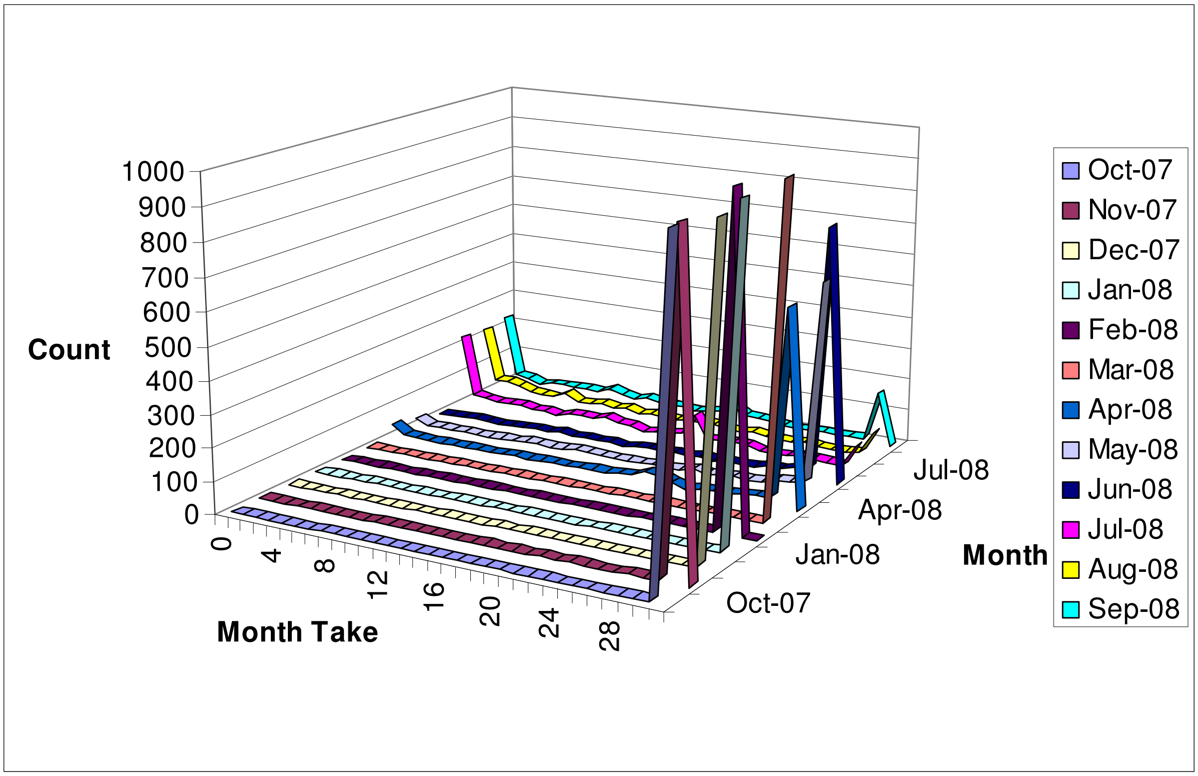
In the Day 0 delta surface, for low values of the spot price and “period-to-date” values the delta tends to a non zero value in contrast to a strip of call options for which the delta would tend to zero as the options become more out-of-the-money. The delta for the swing contract tends to a non-zero value because of the swap component of the swing contract. As the spot price increases the delta first increases in a similar way to a call strip but for very high spot prices the delta begins to decrease to that for a swap because the buyer will almost surely exercise on everyday.

In the Day 219 delta surface the contract is fully constrained in the "period-to-date" region from 0 to 146 (40% of the maximum annual quantity) as holder must take every day to minimise the shortfall penalty. The delta in this region is that for a daily swap. Above "period-to-date" values of 146 the swing contract is partially unconstrained and the delta progressively changes from that for a swap at high spot prices to that for a daily call strip as we decrease the spot level. Above "period-to-date" values of 146, the delta decreases because there are less days left available on which to take before the period maximum is reached. In the flexible region the delta as a function of the spot price is similar to the for a call strip. However, where the contract is close to fully constrained it exhibits complex behaviour as a function of the spot price and "period-to-date".

Figure 2 shows the aggregated monthly volume exposure and cashflow distributions for a short position in the same 1 year take-or-pay contract as figure 1. The strike price is flat at 100 and the forward curve is as follows:

Season	Quarter	Price
Autumn	Q4 07	110
Winter	Q1 08	120
Spring	Q2 08	90
Summer	Q3 08	80

Monthly Aggregated Volume



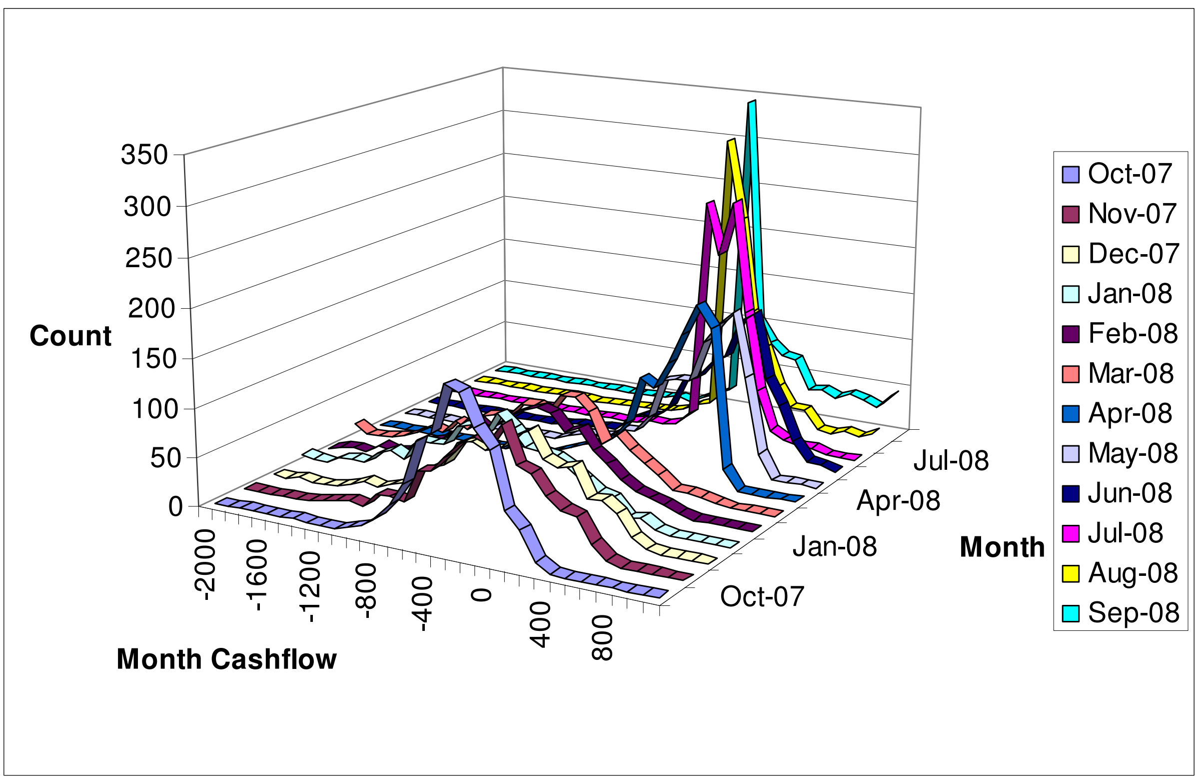


Figure 2: Volume and Cashflow

An example of monthly aggregated volume and cashflow distributions

For fourth quarter 2007, the swing contract is well in-the-money for the buyer and the monthly volumes are equal to the maximum that can be taken for almost all the simulations. The cashflow distributions from the sellers perspective are mostly negative reflecting the loss on selling the gas at a price well below market. However, there are still some positive cashflows resulting from the buyer taking gas even when the spot price is below the contract price because of the minimum bill constraint. In the winter quarter (first quarter 2008) the forward curve is even more in-the-money and so the distributions have similar shapes to fourth quarter 2007. The cashflow distributions are wider because of the increased absolute price volatility caused by the higher prices and the price distributions are wider due to being further into the future. The autumn and winter distributions are similar to that which would be obtained with a swap contract (i.e. high monthly take) since the buyer is taking gas almost every day. The distributions for the spring and summer quarters are quite different – both quarters are out of the money resulting in many more days when the take is zero. The spring (second quarter 2008) cashflow distribution shows a significant proportion of positive cashflows generated by the buyer taking gas to meet the minimum bill constraint when the contract is out-of-the-money but there is also a significant proportion of negative cashflows. The summer quarter (third quarter 08) is most like an out-of-the-money call strip cashflow distribution. With the minimum bill set at 80% the buyer still has to take in this quarter and this is almost always at a loss due to the relative forward price and contract price giving the seller a reasonably predictable profit.

From the above analysis it can be seen that hedging the exposure generated by selling a swing contract is essential to manage the risk. The natural approach would be to delta hedge the contract but this can present a number of practical problems. Spot delta hedging is not generally feasible in most power and gas markets due to difficulty in trading the spot asset, and so the delta with respect to the available liquid futures contracts would need to be calculated. Calculating these futures deltas for long dated swing contracts often presents severe computational difficulties. The contract must be re-valued for a shift in each futures contract which, depending on the length and complexity of the contract, can take many minutes to potentially hours. Furthermore, calculating accurate deltas using either a lattice or simulation based approach is computationally demanding, and can increase the computation time to impractical levels. Finally, delta hedges are generally sensitive to both the rebalancing interval and to misspecification of the model. If the rebalancing interval is much greater than a day and/or the assumed model for the underlying price dynamics does not capture the daily dynamics of the volatility, the delta hedge can have very poor performance.

We therefore look at the performance of intrinsic and static call and put option hedging strategies. The intrinsic strategy is based on the assumption that the spot price follows the forward curve with certainty. The optimal decisions under this assumption yields the static hedge. The hedge involves taking positions in the forward contracts with underlying volumes equal to the negative of the static strategy take volumes. Since the spot price generally does not follow the forward curve exactly then the intrinsic hedge will be an imperfect hedge. The intrinsic hedge can be improved considerably by adding static call and put option positions. The static hedge can be calculated by searching for the positions which minimise the hedging error over a set of simulated outcomes for the hedging strategy.

Figure 3 illustrates the performance of a standard intrinsic and static monthly forward, call and put hedge for the same 1 year take-or-pay swing contract used above.

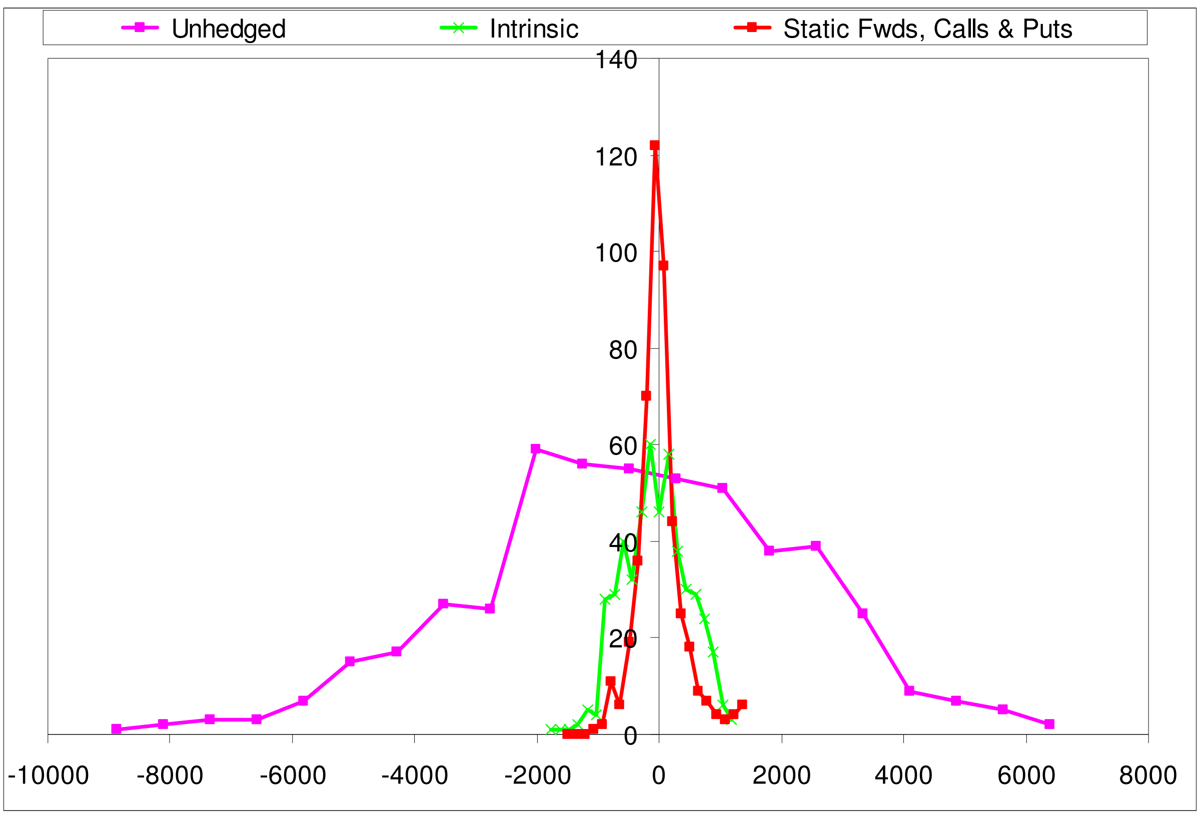


Figure 3: Cashflow Distributions

For Unhedged, intrinsic distributions, along with static forwards, calls and puts

The purple line ('Unhedged') shows the distribution of cashflows for an unhedged swing contract from the perspective of the seller, the green lineI ('Intrinsic') shows the distribution of cashflows for the sold swing contract together with the intrinsic forward contract hedge. Finally the redline line ('Static Forwards, Calls, & Puts') shows the distribution of cashflows for the sold swing contract together with a hedge based on monthly forwards, calls and puts on the nearest monthly forward contract.

The static hedge provides a significant reduction in the risk compared to the unhedged swing position. Adding static call and put positions noticeably improves the hedge further. A good way to analyse the performance of the hedge is shown in Figure 4.

December 2007 (Autumn)

April 2008 (Spring)

July 2008 (Summer)

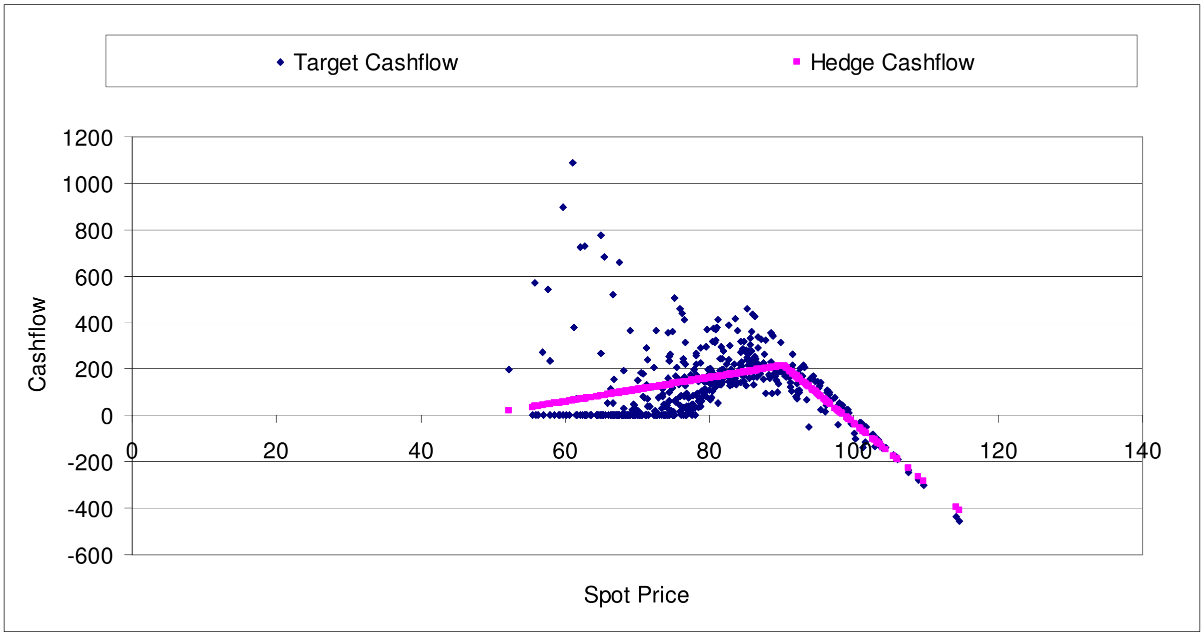


Figure 4: Cashflows versus Spot Price for Swing Contract and Static Forward, Call and Put Hedges

In the panels of figure 4 each dot represents a simulation of the cashflows of the swing contract and the hedge. As we noted earlier in relation to figure 2, for the Autumn and Winter quarters the holder almost always takes gas irrespective of the level of the spot price and so the risk is almost identical to a swap. This is shown by the straight line relationship between the cashflows and spot price for December 2007 and the static hedge for this month is simply a forward position. There are a few simulations in which the spot price is so low (roughly below 80) that the holder does not take on every day of the month and the cashflows are below the straight line. This effect is much clearer for April 2008 and here the hedge can be seen to be formed by a combination of a short forward, a long call and a short put. The exposure in July 2008 is more difficult to hedge because the holder's takes depend on the volume of gas that they have already taken which can have a much wider range than earlier in the contract year. With the objective of minimizing the squared hedging error the optimal static hedge for this month is again a combination of a short forward, a long call and a short put. Different objectives would lead potentially lead to different hedges.

In last month's article we described how the basic take-or-pay contract that we have been discussing here is often further complicated by the addition of make-up (MU) and carry-forward (CF) provisions when the contract is for a multiple year term. In order to hedge MU and CF we need to understand the additional cashflows which are generated by the MU and CF decisions. These can be represented by the following end of penalty period cashflows as seen from the sellers perspective:

$$\Delta V_{MU}(K) \quad (1)$$

$$\Delta V_{MU} = \left\{MB - \{-\Delta V_{CF}\}^{+} - \sum \Delta V\right\}^{+} \quad (2)$$

Where ΔV_{MU} is the change in the MU bank - positive for an increase in the MU bank and negative for recovery of MU, K is the contract price, MB is the Minimum Bill, ΔV_{CF} is the change in the CF bank – positive for an increase and negative for recovery of CF, $\sum \Delta V$ is the sum of the daily takes for the year and $\{x\}^{+} = \max(0, x)$. When the MU bank increases we have a positive cashflow equal to the product of the size of the MU increase and the contract price (MU bank increases happen automatically when the annual take is less than MB reduced by the CF decision as given by equation (2)), conversely when the buyer recovers MU we have a negative cashflow given by the same equation. Therefore, assuming the intrinsic known future decisions, we can hedge MU with an appropriate forward position in cash. In reality, the decisions depend on the spot prices and so MU and CF has some delta associated with it. Therefore, the intrinsic cash position will need to be adjusted regularly, in the same way as the intrinsic forward positions.

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