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Japanese Reset Convertible Bonds and Other Advanced Issues in Convertible Bonds
Or
"Sometimes it takes a PhD to figure out a structure designed by a high school dropout"

By: Izzy Nelken

Abstract

Japanese reset convertibles have received some notoriety after the well publicized losses at the Union Bank of Switzerland (see for example "UBS to upgrade its derivatives losses to $421m", Financial Times, January 31, 1998).

In this paper, we discuss several advanced issues relating to Japanese "style" convertible bonds. The convertible bonds, issued by several Japanese and Taiwanese issuers (among others) have some unique features.

This paper will also mention two more interesting items relating to non-reset convertibles:
1) The duration of a convertible bond.
2) How correlation impacts convertible securities.

Introduction

Between 1995 and 1998 several Japanese banks issued "jumbo" convertible bonds with large outstanding amounts. In the mid-1990's the Japanese banks were considered quite risky as they had large real estate exposures. As a result of worsening conditions the Japanese banks required more capital. Equity issuance was out of the question since stock markets were depressed. Straight bond issues would have required a high coupon yield. This would have placed a burden on the banks' treasury departments.

Convertible bonds were seen as a reasonable tool to raise capital. Investors in such convertible bonds wanted some sort of “insurance” should the issuing bank’s stock decline. The Japanese banks found it much easier to sell convertible bonds if the reset feature was included.

Prior to its merger with the Bank of Tokyo, Mistubishi bank issued a $2 Billion US dollar deal in September 1995. The deal had a reset clause since it would have been redeemable for cash if the share price at maturity is less than half of the original conversion price. As operating conditions in Japan worsened, the banks needed to raise more and more capital to operate within the BIS regulatory capital guidelines. More and more reset convertibles were issued.

Currently, reset convertibles are fairly common in the Japanese domestic market and have also been issued in other Asian countries.

The conversion feature is in some cases upward and downward. In most cases, however, it is only downward. A decline in the share price will usually cause a decline in the price of the convertible. By including a reset feature and ensuring that the convertible bond is again convertible to par worth of stock, the convertible’s price increases as compared to a non – reset convertible.

Usually the downward reset is limited by a floor. That is, if the issuer’s stock declines by a lot, the holder of the convertible will only be compensated for some of the decline. This is to ensure a limit on the potential dilution of the issuer’s stock in case of conversion.

The reset feature

In a reset convertible, the conversion price resets at certain dates as a function of the stock price during the proceeding period. When the conversion price is reset downward, it makes the bond more expensive. This is done to compensate the bond holders for a reduction in the price of the stock. Many convertible bonds exhibit several reset dates. Of course, the conversion price on the second reset date, depends on the conversion price which was set on the first reset date. This in turn depends on the initial conversion price. If the bond has three reset dates, the conversion price on the third reset date depends on the conversion price which was set on the second date which depends on the conversion price of the first reset date etc.

In some convertible bonds, the conversion price may not reset downward below a certain multiplier of the *first* conversion price. Other convertibles, like in our example, allow the conversion price to reset based upon the *previous* conversion price.

Note that in some convertible bonds, the conversion price may also be reset upwards. In our example, this does not happen since the upper limit on the conversion price is set to the previous conversion price multiplied by 1.

Modeling of reset convertibles

We analyze convertible bonds using a multi-dimensional tree (or pyramid). Our algorithms have been described before in "Costing the Converts", by Cheung, W. and Nelken, I. Risk Magazine, Vol. 7, No. 7, July 1994 and "Fervour of the Convert", by Nelken, I., Asia Risk Magazine, April 1996.

When trying to apply tree based methods to solving Japanese reset convertibles, one realizes that the changing conversion price makes the problem "path dependent". Path dependent problems are known to be very difficult to price with a tree based methodology.

The difficulty is that when we arrive at a particular node, these may be very many conversion prices possible at that node. Thus, it is no longer sufficient to know the stock price and interest rate at that node. We also need to know the conversion price. However, there may be very many possible conversion prices as they depend on the past history of the stock.

This is known as "a dropout from high school can easily create a problem that will challenge a Ph.D."

In any case, we have completed the creation of a model which solves for reset convertible bonds. This is implemented in a kind of "super trees". One of the features of this algorithm is that it does not require much more time than solving for a non-reset convertible. It does not rely on Monte Carlo techniques, neither does it spawn a new tree at each possible reset date. Instead, the tree is "enhanced" so it can keep track of many conversion prices.

It is very tempting to ignore the reset feature. However, as is shown below, the computed bond prices (and Delta hedge ratios) will be quite different between reset and non-reset convertibles.

Example

We examine the relationship between two convertible bonds.

- The non – reset convertible is convertible into 7 shares of the underlying stock

- The reset convertible is initially also convertible into 7 shares of the underlying stock (conversion price $142.857 per $1000 face value of bond).

In addition, there are three reset dates. On each of those dates, the conversion price may be reset *downward* only.

On 1-Sep-2005 the conversion price resets to be equal to the share price, provided that this will not reset the conversion price to below 50% of its previous value.

This repeats again on 1-Sep-2006 and on 1-Sep-2007.

Assume that on 1-Sep-2005, the share price is equal to $80. The non-reset convertible will have a conversion value of $560 and will be out of the money. It will probably trade close to its bond equivalent basis, probably below par. The reset convertible, on the other hand, will reset its conversion price to $80. The conversion value will be $1000 (by definition) and the convertible will trade above par.

On 1-Sep-2006, the share price has declined some more to $60. The non-reset convertible will have a conversion value of $420 and will be even more out of the money. We can not say for certain what happens to the reset convertible.

If, as in our example, the previous conversion price was $80, the new conversion price will be reset to $60. The new conversion value will be $1000 (by definition) and the convertible will trade above par.

But consider another case where on 1-Sep-2005, the stock price has been $150. In this case, the conversion price was not reset and stayed at$142.857. Now (on 1-Sep-2006) that the share price has declined to $60, we can not reset the conversion price to below 50% of its previous value. The new conversion price will, therefore, be reset to $71.42857. The conversion value of the bond will be $840.

The important feature of these bonds is that the conversion value is path dependent. It is not enough to know the stock price today to compute the conversion value.

If we continue with this analysis to the third reset date, we will have even more possible conversion prices.

Bond Prices

Figure 1 is a drawing of the bond prices of the non-reset convertible and the reset convertible. We also plot the “reset premium”. This is defined as the difference on prices divided by the price of the non-reset bond.

When the stock price is in the “default region”, the reset and non-reset trade close to each other. Even if the reset convertible allows to get more shares, the shares are close to worthless and do not contribute much to the bond price.

At very high stock prices, the conversion price of the reset is not likely to reset downwards, and again, the reset and non-reset trade close to each other.

At intermediate bond prices, there are substantial differences in price between the reset and non-reset bonds. As the graph shows, the differences can be upwards of 10%.

Delta hedge ratios

It is even more instructive to study the Delta hedge ratios of the reset and non reset convertible bonds.

Figure 2 is a chart of the Deltas of both bonds. Figure 3 is a close up in which we have concentrated on the “interesting” region which highlight the differences between the reset and non reset bonds.

As UBS found out to its dismay, it is the Delta of a reset convertible which causes problems. In a typical (non-reset) convertible, the Delta declines with as the stock price declines. Thus as the convertible becomes “out of the money” and moves into the “bond equivalent region” it becomes less sensitive to the stock price.

In the reset convertible, on the other hand, the conversion price declines with the stock price. Thus as the stock price declines below a certain threshold, Delta *increases* (see Figure 3). Now, consider a trader with a hedged position. They are long convertible bonds and short stocks. As the share price declines, the Delta increases, the trader is in the difficult position of having to short even more shares. So they need to borrow more shares and sell them short. This, in turn, puts an even greater downward pressure on the share price. Thus the trader is forced to “go against himself”. In addition, this strategy is followed by many other convertible hedgers and the stock is caught in a “short squeeze”. The short borrow rates move right up and the positive carry that was obtained by a long position in the bond and a short position in the share, turns into a negative carry.

The carry is given by:
Carry = Coupon – Delta * (Dividends + Stock Borrow Fees)

As the Delta increased and stock borrow fees became very high, the positive carry turned into a negative one.

At extremely low stock prices (the left hand side of Figure 2), we begin to see the effects of the bankruptcy region. Note that extremely low stock prices hurt the reset convertible more than they hurt the non-reset bond. The reason for this is that the reset convertible can only adjust its conversion value so far. In a reset convertible, if the stock price declines to moderately low levels, we can reset the conversion price to the current stock price. However, if the stock price declines to extremely low levels, the conversion price adjusts to the previous conversion price multiplied by a factor (in our case, 50%). Thus at moderately low stock prices, the conversion value is again par. At extremely low stock prices, the conversion value is sub-par. Thus it stands to reason that the price difference in low stock regions for reset bonds will be higher than that of non-reset. Add that to the bankruptcy effect which impacts on both the reset and non-reset bonds and the pattern becomes understandable.

Gamma ratios

Option traders are usually taught to "avoid negative Gamma like the plague". Gamma is the second derivative of the price of a derivative instrument with respect to the underlying. We review the first terms in a Taylor series

$f(x+h) = f(x) + h*f'(x)+h^2/2*f''(x)+\ldots$

The trader does not know which way the underlying will move. Suppose the trader is Delta hedged so that $f'(x) = 0$. Then whichever way the underlying moves we have

$f(x+h) = f(x) + h^2/2*f''(x)$

If $f''(x)$, which is known as Gamma, happens to be negative, the trader will lose whichever way the underlying moves.

On the other hand, positive Gamma adds to the price of the instrument. This lead to the old-timer expression "the 'benter' the better". This means that the more Gamma an option has, the better it is to hold.

In Figure 4 we plot the Gamma of both the reset and non-reset convertible. Notice the large negative Gamma which exists in the reset instrument. Also notice that the negative Gamma area begins earlier in the reset convertible than in the non-reset bond.

We call Gamma the "cost of the baby sitter". If the absolute value of Gamma is high than any small movement in the underlying will require a change in the Delta hedge ratio. Therefore, the trader must "baby sit" the hedged position. On the other hand, if Gamma is close to zero, then a hedged position will continue to remain hedged. We note that reset convertibles are instruments whose Gamma is negative and lower than non-reset bonds. The absolute value of Gamma, on the other hand, is higher for reset bonds than for non-reset convertibles. Therefore, they require a lot more hedging.

Conclusion of Reset Bonds

The reset convertible is a very interesting bond. Its price and hedge ratios depend on a variety of factors. These include the reset dates, the stock multiplier on each reset date which is used to determine the conversion price and on the minimal (and maximal) amounts by which the conversion price can be modified.

These relationships are quite complex and an adequate model is essential. Fortunately, such a model has recently become available from Super Computer Consulting Inc. For more information, please give us a call.

Two more interesting points related to convertible securities:

Duration

The duration of non-convertible bonds decreases as their coupon increases. This familiar effect is due to the fact that the higher coupon bonds deliver more cash flows near the start of their life as compared to lower coupon bonds which deliver cash flows towards the end of their life. For example, all other things being equal, a 7.5% coupon bond will have a lower duration than a 3.5% coupon bond. A zero coupon bond has the highest duration of all.

Convertible bonds, on the other hand, sometimes exhibit an opposite effect. Raising the coupon causes the duration to *increase*. Let us understand this phenomena.

Compare a 7.5% coupon bond that is convertible to four shares with a 3.5% coupon bond which is convertible to eight shares. The holders of the 7.5% convertible will have less of a propensity to convert their bonds (as they receive a higher coupon). Thus the expected lifetime of the bond increases which will cause the duration to increase. So with convertibles we have two contradictory effects:

High coupon → Lower duration (as in normal bonds)
High coupon → Lower propensity to convert → Longer life time → Higher duration

These two effects are contradictory and it is difficult to ascertain which is the stronger of these. A model is useful in this regard.

Correlation

It is clear that the correlation between stock price and interest rates has an effect on the price of the convertible. A table of correlation numbers and prices follows:

Stock/Rate correlation	**Convertible Bond Price**
1	134.00
0.5	127.57
0	120.79
-0.5	113.82
-1	106.54

In this example we see a difference of about 25% between the price of the convertible when the correlation assumption is 1 and –1. This specific example exhibits quite a large sensitivity to correlation. Typical convertible bonds we have observed, may have price differences in the area of 15-20%.

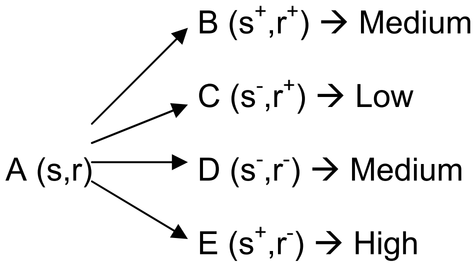
Consider, if you will, another correlation product, the “crack spread option”. This option has a payout that is determined by the difference, at expiration, between the prices of raw oil and heating oil. For an example option, we obtain the following prices:

Heating Oil/Crude Oil correlation	**Spread Option Price**
1	1.24
0.5	2.866
0	3.807
-0.5	4.531
-1	5.117

The spread option’s price is, of course, very sensitive to correlation. The higher the correlation between the prices of both underlying instruments, the closer the two underlying instruments are going to be to each other.

Thus the spread option exhibits a price sensitivity to correlation of about 400%, while the sensitivity of the convertible is about 25%. We now explore the sensitivity of the convertible to correlation and why that sensitivity is not as great as the correlation sensitivity of a spread option.

Consider a typical node in a quadranary (quadro) tree which models the convertible bond. At node A, we have a stock price of **s** and an interest rate of **r**. One period later, the stock price may rise to $\mathbf{s}^+$ or fall to $\mathbf{s}^-$ .Similarly, the interest rate may climb to $\mathbf{r}^+$ or may decline to $\mathbf{r}^-$



In the quadro tree, node A has four descendent nodes which correspond to the four possibilities:
Stock Up, Rates Up – Node B
Stock Down, Rates Up – Node C
Stock Down, Rates Down – Node D
Stock Up, Rates Down – Node E

With each node, we also associate a probability of arriving at that node. The four probabilities are P_B, P_C , P_D and P_E.

The precise details associated with the quadro tree have been described in our book “Option Embedded Bonds”, I. Nelken, Ed., published by Irwin Professional Publishers, Burr Ridge, IL.

The node B has two effects: the high stock price increases the price of the convertible while the high interest rate reduces it. Therefore, the price of the convertible at node B is medium. At node C, the price is low since the stock price is low (reducing the price) and the interest rate is high, again, reducing the price. At node D the price is medium and at node E the price is high.

Consider a high correlation between stock prices and interest rates. A high correlation will increase P_C and P_E and will decrease P_B and P_D

So, in effect, we are taking the average of a high number and a low one and the result is in the middle.

On the other hand, suppose the correlation is negative. Now, P_B and P_D are high. So we are taking the average of two medium numbers – the result again is medium.

Of course, the convertible has a lot of embedded options and these will change the price of the bond at each of the nodes so it is hard to generalize from this discussion.

Figure 1

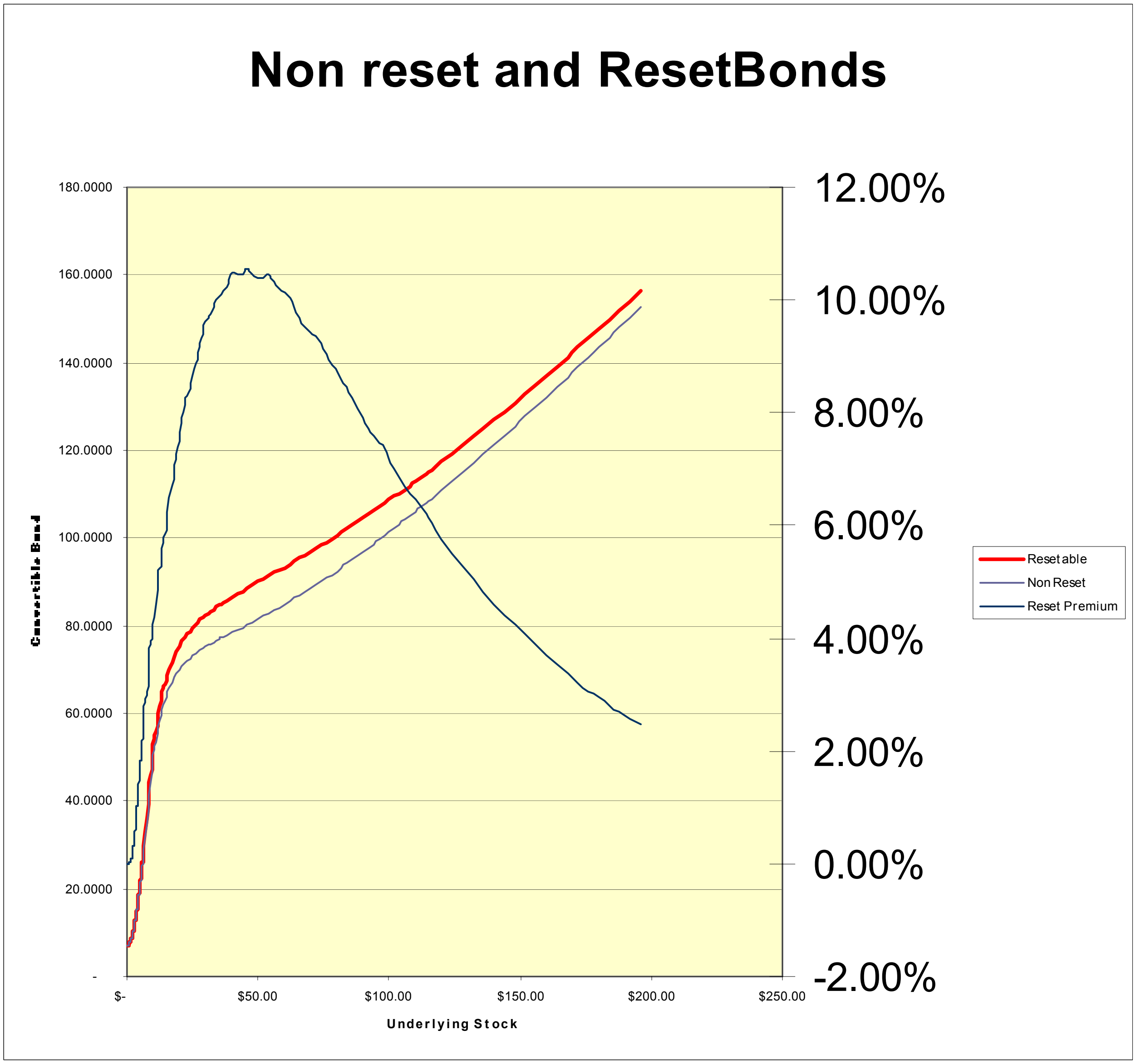

Non reset and ResetBonds
180.0000
160.0000
140.0000
120.0000
100.0000
80.0000
60.0000
40.0000
20.0000
-
$-
$50.00
$100.00
$150.00
$200.00
$250.00
Underlying Stock
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
-2.00%
Resetable
Non Reset
Reset Premium

Figure 2

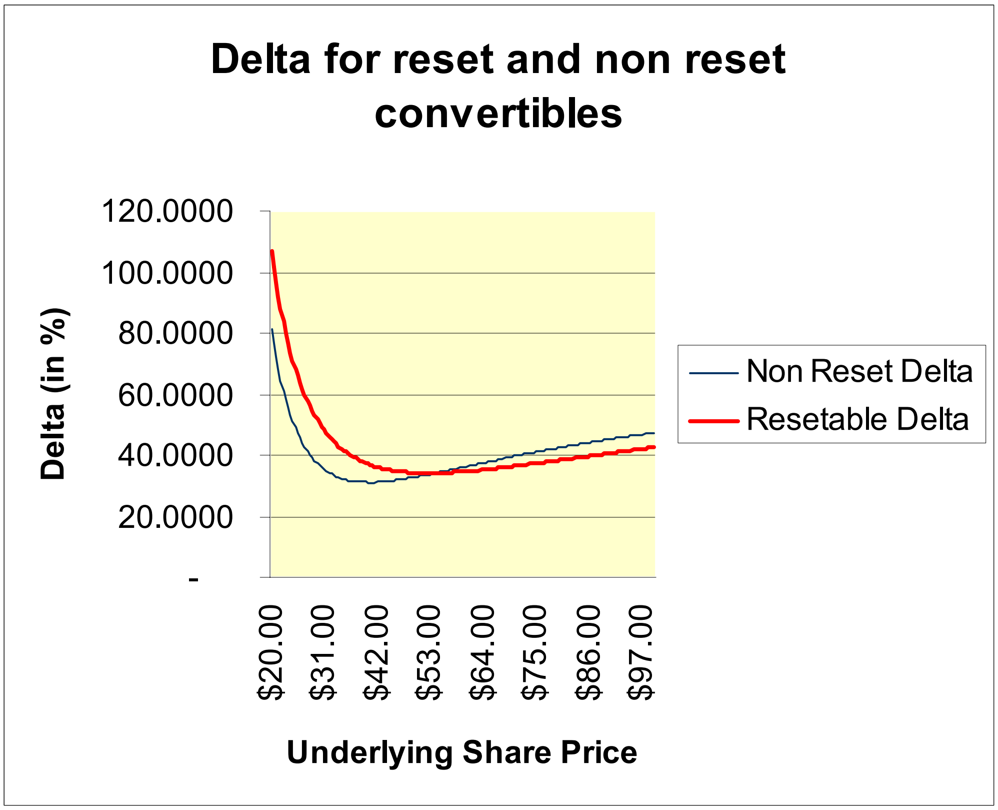

Delta for reset and non reset convertibles
120.0000
100.0000
80.0000
60.0000
40.0000
20.0000
-
Delta (in %)
$20.00
$31.00
$42.00
$53.00
$64.00
$75.00
$86.00
$97.00
Underlying Share Price
Non Reset Delta
Resetable Delta

Figure 3

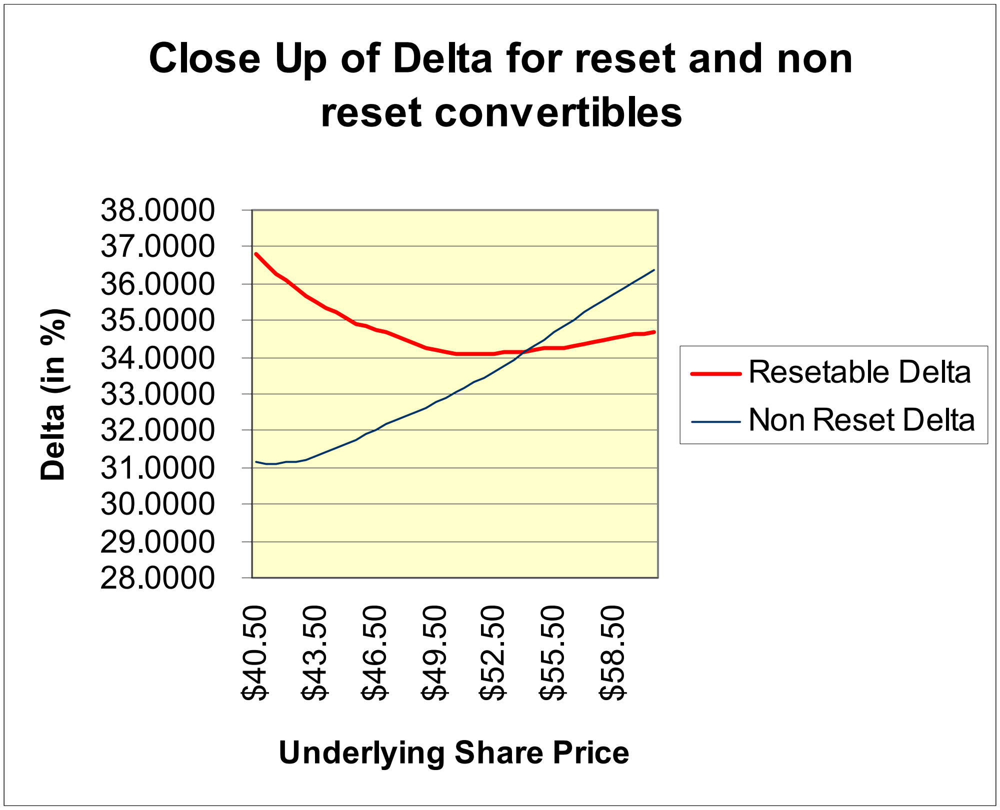
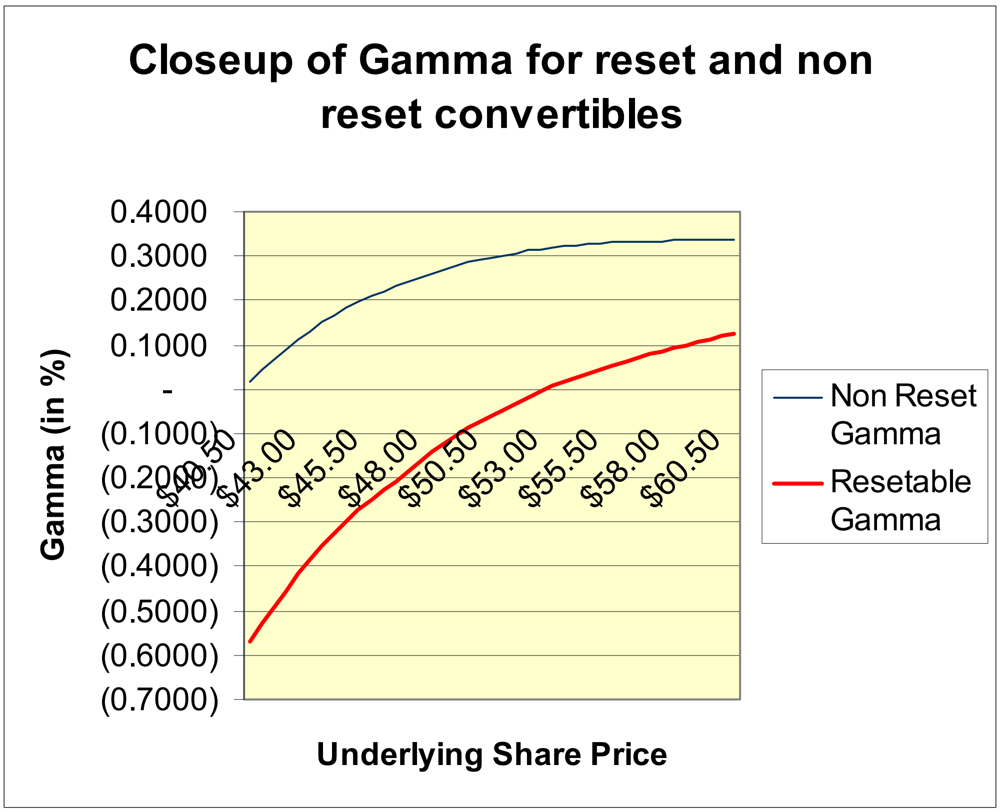

Close Up of Delta for reset and non reset convertibles
38.0000
37.0000
36.0000
35.0000
34.0000
33.0000
32.0000
31.0000
30.0000
29.0000
28.0000
Delta (in %)
$40.50
$43.50
$46.50
$49.50
$52.50
$55.50
$58.50
Underlying Share Price
Resetable Delta
Non Reset Delta

Figure 4


Closeup of Gamma for reset and non reset convertibles
0.4000
0.3000
0.2000
0.1000
-
(0.1000)
(0.2000)
(0.3000)
(0.4000)
(0.5000)
(0.6000)
(0.7000)
Gamma (in %)
$40.50
$43.00
$45.50
$48.00
$50.50
$53.00
$55.50
$58.00
$60.50
Underlying Share Price
Non Reset Gamma
Resetable Gamma