An Option on Options

We speak to **Elie Ayache** at ITO33, who dissects various layers of complexity in Asian Convertible Bonds and ASCOT and sheds light on their popularity

Tell me about some of the areas ITO33 has been focusing on recently?
Recently there has been some action on Asian Convertible Bonds. These convertibles are being issued by companies based in India (e.g. Welspun 2010), China (e.g., Brillance China 2011) or Taiwan (HannStar 2008), and what they have in common is they are resettable. This means that the amount of underlying shares you can convert your convertible bonds against, or conversion ratio, is reset or readjusted periodically, typically every year.

Note that the conversion ratio is reset periodically to benefit the holder. If you buy a standard convertible bond, you earn a uniform stream of coupons or the principal accretes until maturity, in the case of zero coupon bonds. The whole idea is that you can convert this bond into a pre-specified amount of underlying shares of the issuing company. Typically, if the underlying share price rises, it may become interesting to convert the bond into shares and become a shareholder in the company. But that's not the case if the stock price falls.

In resettable convertible bonds, the resettable feature compensates you against a fall in the underlying market by allowing you to readjust the conversion ratio at the reset date to convert against a larger amount of underlying shares if their price is lower.

Another way of putting it is to say that the convertible bond is always readjusted to remain at the money. The "strike" of the convertible bond, also known as the *conversion price*, can be defined as the nominal divided by the conversion ratio. For instance, if the convertible bond has a nominal amount of $100 and is convertible against four underlying shares, the strike is $25 because you are indifferent between being owed $100 by the company or owning four shares worth $25 each. Your hope is that the underlying share will rise above $25. For example, if share price rises to $40, your conversion value will be $160.

If shares fall to $10, converting will only get you $40. But if the conversion ratio is now adjusted to 10 (or the conversion price reset to the market value of the underlying share), you may now convert against 10 shares, which is worth $100 again. So you are at the money again.

This is what ITO33 has been focusing on recently because more and more of our customers trade those Asian convertible bonds.

Could you elaborate on the complexity of resettable convertible bonds?
Pricing of resettable convertible bonds can be very challenging mathematically and numerically because of the complexity of the reset feature. The problem is path-dependent and you have to sample, in your grid, not only the underlying share price, but all the future possible conversion prices.

As they are issued by companies based in India, China, Taiwan or Japan, these bonds are usually also cross-currency. The investors usually buy these convertible bonds in US dollars, but the underlying share is denominated in the local currency, rupee, Taiwan dollars or RMB. This adds another complexity on top of the reset feature.

Not only that, but we have recently handled clauses which say that you can readjust the conversion ratio downwards only if the underlying shares are below a certain level. So there are triggers now being added to the reset feature. This is another layer of complexity.

Over recent months, we have been bombarded by requests by customers virtually every week. Every time there is a new issue of convertible bonds, they ask us to add support for the new feature, whether it's cross-currency or triggers on the reset, etc.

So this means more calculations have to be done for the resettable convertible bonds?
Not only that, but we have to keep evolving our numerical and mathematical models and support the continuously evolving data model. If the customer wants to price a convertible bond with a new feature, we have to provide him with the tables and graphical interface where he can enter the terms of the bond. It is not only a matter of computation, but also a matter of data modeling.

What are the additional data that you'll have to handle?
You end up with a larger and larger set of data that you need to feed into the pricing equation and engine. For instance, resettable convertible bonds require, on top of the traditional terms describing the bond (coupon stream, accretion, cross-currency, etc.), the dates when you may reset the conversion price, the reset rule, etc.
Typically, you cannot reset the conversion price downwards forever. As the share price gets closer to zero, the issuer won't allow you to convert into an infinite number of shares. The reset rule provides that the conversion price is floored. This floor, below which the conversion

price may never go, as well as the trigger level, only below which you may readjust, become an integral part of the description of the convertible, further complicating the data model.

What are the different solutions ITO33 has been developing to cope with all these new challenges?
We have been developing derivative pricing engines (in C++) for eight years now. They compute the solution of the derivative valuation problem. When credit risk is involved, the valuation model is similar to Black Scholes, only more general. It takes into account the probability of default of the issuer. We use some basic theoretical models which have been well accepted.

Recently we've been focusing on developing more of an industrial process. Whenever our customers have new requests, such as the handling of new issues of convertible bonds, we have to be very reactive. Adding the new feature, testing the pricing tool, releasing the upgrade of the mathematical library, the data model and the graphical interface are things that we have to achieve in the few days following the customer's request.

Besides Asian convertible bonds, what other areas is ITO33 also focusing on?
We're also focusing on Asset Swap Convertible Option Transaction (ASCOT), which also adds substantial complexity.

Credit risk has been volatile and is of concern to everyone. Traders of convertible bonds who want to eliminate credit risk exposure, enters into an asset swap, which is a popular strategy. Hence, they hedge away the credit risk inherent in convertible bonds by swapping with someone willing to take the credit risk.

Imagine I am a hedge fund or convertible bond trader really interested in the equity aspect of convertible bonds. I want to benefit from the movements of the underlying share by the usual volatility play. To eliminate credit risk exposure, I enter into a convertible bond asset swap which splits the convertible bond into two components. I will keep the part which is sensitive to equity and swap the part sensitive to credit risk with another party.

In fact, there are three parties involved. The first is the investor who buys the convertible: I, the hedge fund. I immediately sell it to an investment bank, the second party, who really acts as an intermediary. Indeed, the bond is ultimately sold at par to a third party, the final credit risk buyer, a. k. a. credit protection seller, who will support all the credit risk. As a matter of fact, the investment bank and the final credit protection seller enter into a swap, on top of their transaction at par. The investment bank receives back the fixed coupons of the convertible against paying floating plus spread to the protection seller. If the convertible bond should default, the swap would nevertheless remain in place. The bank would still earn the CB coupons, as they were guaranteed, and the protection seller would still earn the spread over floating. Usually the swap has a maturity, which is either the maturity of the CB or a CB put date. What the bank gives me in exchange is only an option to buy back the convertible bond. Obviously, I won't exercise this option in case of default.

Usually the credit spread of the issuer increases prior to default. But even then, the credit deterioration and the fall in value of the convertible bond will not hurt me because I do not hold the bond, but only a call option on the bond. If credit spread improves and the underlying share rises, I can exercise the option to buy back the convertible bond from the bank. What we do here is value this option on the convertible.

Thus, the ASCOT is an American option written on the convertible bond. It is really a compound option, as the convertible bond is ultimately an equity option.

When I want to exercise my option, I will have to pay, as its strike price, the unwinding value of the asset swap involving the bank and the credit protection seller. So the CB option is ultimately a compound option with variable strike price. This tells you the level of complexity. Not to mention that the convertible bond may be resettable or cross-currency, etc. So this is what ITO33 has expertise in today. To put it briefly, suffice it to say that we are the leading experts in the pricing of ASCOTs. This presupposes that we are the leading experts in the pricing of convertible bonds.

Could you explain to us how the strike price is variable?
The swap value involving the fixed stream of coupon against a floating coupon, which is usually LIBOR plus a fixed spread agreed at inception of the swap between the bank and the third counterparty, depends on time and interest rates.

How popular are ASCOTs right now?
It is popular for people who think that the convertibles are undervalued and expect the underlying value to rise. It's a good way of giving investors the option to hold the convertible without exposure to credit risk. It's increasingly popular among our customers, a few of whom have become leaders in the trading of these kinds of structures.

Today, in the market, it's all about credit risk. On the other hand, volatility is increasing on the equity. ASCOT is sitting at the heart of the whole problem because it is sensitive to the volatility of the underlying shares and to the volatility of the credit. Being an option on the credit, it's very relevant. This is why it's becoming more popular.

Because strike price is variable, isn't that a risk in itself?
The only risk here is interest rate risk. Otherwise, it varies deterministically over time. So it is not as risky as the credit component.

When you buy a convertible, you are exposed to three risks, equity price risk, credit risk and interest rate risk. Here you are getting rid of credit risk only; you're still exposed to interest rate risk, which you may hedge otherwise, and to equity risk which you want to keep anyway.

Could you explain in greater detail the solutions ITO33 has to help investors benefit from ASCOT and Asian Convertible Bonds?
By holding ASCOT, you profit in the meantime by being long an equity option: by playing the volatility of the underlying share. You are basically long in option on the convertible, which is itself an option on the underlying share. Hence, you are ultimately long an equity option. You make money as the underlying shares gets more volatile, but you're not exposed to credit risk.

The model that we solve for the ASCOT and CB option tells you exactly the optimal moment to call back the whole asset swap. Why we can specialize in this area successfully is because we have a model which takes into account stochastic credit spread. If the asset swap is a way of hedging credit risk, it will be very sensitive to credit risk volatility. To price that option, you need to have a model where credit spreads are stochastic. If credit spread improves, the issuer is no longer risky. That will be a trigger for you to call back the whole deal and ultimately convert the convertible.

Apart from interest rate risk which is of minor importance in this whole thing, the two factors of risk which directly affect the value of the CB option are credit and equity risk. Therefore, you have the volatility of the credit spread and of the underlying share, which are the two processes we model. It is quite challenging to have an efficient pricing engine which takes into account two dimensions of risk like that, but this is what we have and it is one of the reasons why we have become experts in that field.

We have been working on convertible bonds for about eight years since our company started in 1999. Asian convertible bonds and ASCOT are recent areas where we have built on our very strong background and mathematical and numerical platform.

In the resettable bonds, which are really hard to solve, the numerical methodology that we have is very superior to what people currently use, which are binomial or trinomial trees. What we have is finite differences and PDE. Our numerical methods are very advanced, accurate and very fast. This has greatly profited to resettables and to ASCOT, which add layers of complexity.

In what ways are ITO33's methods superior?

I was a very convinced reader of books by Paul Wilmott from the start. He was the first to introduce the use of PDEs in the financial field, instead of trees. I knew we were going to solve derivatives which were very complex, like convertibles, or exotics, anything which is non-vanilla.

As soon as you start pricing derivatives which are non-vanilla, trees become useless or at least very poor in terms of accuracy. You cannot really adapt the nodes of the trees, which are not very flexible as numerical methods. For instance, the binomial tree imposes on you a number of nodes and you cannot play with it. You may end up using a lot of computational power in areas where you don't need it and not using it in areas where you need it.

Also in trees, you cannot adapt the grids any way you want. If you are using the methods Paul Wilmott explains in his book, which are finite differences, you can build adaptive grid or meshes, where you put nodes in areas where you know there will be some difficulties in the solution and fewer nodes in areas where you know the numerical solution will be smooth and well behaved.

You can really re-engineer your grid to best adapt to the convertible, barrier option or American option that you are pricing. This way, you get the best accuracy using the smallest amount of computational time. If you want the pricing model to be the fastest and the most accurate, you can only get this flexibility in finite differences, not trees.

Everything we did from the start was based on PDEs, finite differences and finite elements, not on trees. Now in large institutions and banks, I'm sure the quant teams are using finite differences. As everyone has become a fan of Paul Wilmott and has read his books, everyone has been developing these things.

The good news for us is that those things are difficult to maintain and develop. Companies like mine are needed to maintain the code which is more difficult than trees. Anyone can do trees very quickly; they can even do it in Excel. Derivative pricing has become more of an engineering problem that needs to be maintained. My team has been maintaining our product for eight years.

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In banks, people stay in place one or two years and then change jobs, so it's not easy to maintain such an engineering project. Perhaps only a handful of companies working on convertibles have begun using PDE or finite differences, but they are not as evolved as we are. After all, it took us eight years to get here.

Hence, I believe we have this edge over them because we've been doing it longer and have faced more problems. You cannot find these solutions written in books; it is something you discover while doing it. It's a learning process; we have found many tricks and ways of getting around the problem by solving the problem. From all the feedback from our customers, we've fixed many of the bugs over time. This kind of process can only unfold in time.

In terms of speed, how long does it take you to write or execute a pricing model?

Today we have the good fortune of having a well developed code, which has evolved incrementally. When customers ask us to integrate new features, it takes maybe two days because we can add relevant code without having to reprogram the whole finite difference routine for every new convertible. The object hierarchy of our C++ library also helps. It only takes us a day or two to add new features.

Execution time depends on the speed of the computer. Bear in mind that all our pricing engines are used in real time by traders. If you want the pricing of the convertible and the computation of the delta, gamma, vega etc, it will take only a few milliseconds, and everything is recomputed every time the underlying share price ticks.

Of course binomial trees can be quicker, but they are very poor in accuracy. PDE is the best trade off between speed and accuracy. Again a good measure of how quick you want it is real time. As soon as the stock ticks, you'll want the convertible bond price to be recomputed immediately on your Excel sheets or your front-office tool.