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Master Essay

“The analysis of attractive rates offered under Dual Structured Notes without principal protection, regarding the probability to occur and the operation at market prices of the implicit options”.

Masters program: Finance (One year)

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Table of contents

Abstract	3
1. Introduction	4
Chapter 1: Background of structured notes	7
2. What are the structured notes?	7
3. Background of the structure notes issued by the local bank in Mexico.	9
3.1. Amounts of structured notes issued and period of allocation.....	9
3.2. Rates offered in the structured notes issued and their equivalent return paid.	9
3.3. Customers of the structured notes issued.	11
3.4. Types of structured notes issued by the local investment bank.....	11
4. General description and operation of the Dual Structure Notes	13
4.1. Description and operation of the Dual Structured Notes issued in MXN.	14
4.2. Description and operation of the Dual Structured Notes issued in USD.....	17
4.3. Issues identified considering the Dual Structured Notes operation.....	20
Chapter 2: Method and Data	21
5. Method of research.....	21
5.1. Fixed return (Bond).....	21
5.2. Payoffs and profits (implicit option-variable return).....	21
5.3. Critical FX prices estimation.....	22
5.4. Options pricing and VaR.....	23
6. Data	25
Chapter 3: Results	27
7. Results	27
7.1. Dual Structured Note in MXN results.....	27
7.2. Dual Structured Note in USD results.....	30
8. Conclusion.....	34
9. References	35
Appendix A: Figures	36
Appendix B: Tables.....	41

Abstract

This paper has the purpose to determine whether the attractive rates offered by a local Investment Bank in Mexico under structured products, more specifically under structured notes without principal protection denominated “Dual Structured Notes”, are plausible to get, showing whether the strikes of the implicit options were chosen within critical price values for the foreign exchange rate MXN/USD and as consequence whether the options implicit in the notes were operated at market prices.

In order to make an analysis of the Dual short-term structured notes, we are going to focus in the option implicit in the notes and the underlying asset. Firstly, we are going to calculate the critical exchange rate prices in the left and right tail of the term ahead MXN/USD exchange rate stochastic variable distribution. Secondly, we are going to compute the options price at the original strike and at those critical values, in order to compare it and determine whether those instruments were sold at market prices within the range. Thirdly, we are going to estimate the analytical value-at-risk (VaR) as a tool for the investors to know the risk of this kind of products.

As a result of this work, such actors as pushers, advisors and managers that encourage investors to take structured notes without any reference to their risk profile, will be able to provide a guidance for investment decisions in order to assess investors the risks of these notes based on critical prices for the exchange rate and VaR information.

Additionally, these patterns have the potential to provide a technical background for the Mexican and International Regulators to incorporate the minimum requirements and rules that financial companies should implement in order to issue and allocate structured notes without any principal protection to their customers. These results give also a possibility to develop the base for the inference if the implicit options or other financial products, that are sold or bought to partners of the same Financial Group, are operated at market prices.

1. Introduction

The structured notes of our concern are short-term debt securities structured with a combination of bonds and short call or put option over a foreign exchange rate, denominated Dual Structured Notes, issued in Mexican pesos (MXN) or American dollars (USD) by a Local Investment Bank in Mexico¹.

The highest rates offered by the notes and the particular operation of the bank having as counterparty for the implicit options its brokerage partner, gave us to define the next research questions:

“Did the high rates offered by the Structured Notes were likely to occur? Did the implicit options operated within firms of the same Financial Group were written at market prices?”

In order to give the answers to these research questions, we identified the next three issues:

1. *Calculate critical price values for the underlying asset FX of the implicit options*

The derivative element, short option, enhances that the return's note (interest and principal repayment) will be linked to the performance of the underlying asset at the maturity of the note, in this case the foreign exchange rate Peso/Dollar (FX MXN/USD).

According to the position of the FX at the maturity compares with the strike of the option, the note could lead to lower returns than those offered in the note or even more in losses of capital, as well as in the payment of the rates offered.

Therefore, the importance to determine whether the corresponding strikes of the implicit options in the notes, were chosen within a probabilistic confidence interval, using the critical price values for the underlying asset FX MXN/USD as triggers.

2. *Determine whether the bank sold the options to its brokerage partner at market prices.*

Given that in order to structure the note the bank acts as seller of the implicit option and its brokerage partner as a buyer, the bank can establish the premium of the options and for instance can manipulate their strike in order to offer high rates in the issued bonds.

¹ Due to the Mexican confidential bank information law, the name of the Local Investment Bank of our study will be omitted. The Bank is part of a Financial Group with a Brokerage and a Services firm as partners. Its core business is the trading of foreign exchange rates, line that has ranked the bank as one of the three main foreign exchange operators for the private sector as well as one of the most important in the interbank sector in Mexico. Another business lines in which the bank has participation are: Derivatives, Fixed income, Retail mortgage loans and Structure products, which have had an important growth within the years 2010 to 2013.

Also, there is a possibility that the decision of the strikes of the options can be taken by pushers or advisors, who could choose strikes not likely to occur in order to offered high returns and to attract more investors. Setting aside the risk profile of the investors, whose knowledge and understanding of the products could be limited, adding the fact that the information include in the prospects could be technical with complex formulas that exemplified the payment of the notes.

These reasons take us to determine whether the options embedded in the notes where sold at market prices. Therefore, in order to answer this issue, we based our work in the Transfer Pricing Legislation principle emitted by the OECD², related with transactions between associated enterprises (The Arm's Length Principle³), that under the local regulation in Mexico is consider in the Credit Institutions Law (2010)⁴, which establish that: "the operations of any nature with any member of the business group or consortium to which the institutions belong, or corporations engaged in business activities with which the institution maintains business ties, *must be agreed on market terms*".

We use the definition of *market value* given by International Valuation Standards Committee (2003): "The market value is the estimated amount for which a property should exchange on the date of valuation between a willing buyer and a willing seller in an arm's-length transaction after proper marketing wherein the parties had each acted knowledgeably, prudently, and without compulsion".

3. *Estimate the value-at-risk (VaR) as a tool for investors.*

The third issue derives of that in theory a short put position can lose a limited amount of money, while a short call position can lose an infinite amount of money. Therefore, we decided to *estimate the analytical value-at-risk (VaR)* for the options embedded in the notes, as a tool for the investors to measure the risk of this kind of products.

² OECD.- Organisation for Economic Co-Operation and Development.

³ The arm's length principle underlying Article 9 of the OECD Model Tax Convention on Income and on Capital, said that: The amount of taxable profits derived by an enterprise that engages in one or more commercial or financial transactions with an associated enterprise shall be consistent with the arm's length principle if the conditions of those transactions do not differ from the conditions that would have applied between independent enterprises in comparable transactions carried out under comparable circumstances.

⁴ The Credit Institutions Law in Mexico (2010), under Article 45-S, establishes the approach for operations made by institutions that have business ties or property with entities engaged in business activities.

Once answered these three issues, our model has the potential to be used as an instrument of international regulators to determine whether the options sold or bought among supervised entities within the same financial group are operated at market prices without privileging the operations.

As well as the VaR calculation will work as a tool to estimate the risk of these kinds of structure products, since investor's point of view, let them to take informed investment decisions according with their risk profile.

The results of our research will be given in the third part of this work. Basing on them we may say that the most of options implicit in the dual structured notes issued were situated within the confidence interval. However, we found some allocations of structured notes which the strike used in the implicit option were far from the critical values calculated for, resulting in highest gains for some investors and biggest losses for the majority of investors.

Finally, this work has a following structure. In the first chapter we observe a background of structured notes, giving a general idea about this financial product and detailed description of the dual structured notes that were issued by Local Investment Bank in Mexico. In the second chapter we tell about our method of research, carefully explain all our steps during the process of estimation and give the information about data we used in the analysis. Our empirical results will be discussed in the third part. At last, the conclusion contains the general inferences about the whole research.

Chapter 1: Background of structured notes

2. What are the structured notes?

Basically structured notes present the financial product which combines the properties of the fixed income instruments and derivatives. The typical structured note includes two components: a classic debt instrument (e.g., bonds, bank deposits, bills of credit) and derivative element (that can be futures, options, swaps etc.) which is linked with some underlying asset. The last one can be presented by fixed-income assets, equities, commodities, emerging-market securities and foreign exchange rates.

So the range of possible structured products is quite broad and any combination of simple instruments may be utilized depending on the investor's preferences. The construction of structured product is called "financial engineering" (McDonald (2013)).

Telpner (2004) adduces the following kinds of structured notes regarding the underlying assets which the note is linked to as the most common:

- Principal-protected notes (PPN) that guarantee the fixed payment at the maturity equaled to 100% of original investments and the growth of value of underlying asset;
- Credit-linked notes whose payment is linked to some event in the credit liability (default of payment, restructuring or bankruptcy);
- Equity-linked notes that produce the income to an investor depending on the change of prices of some equities or stock index;
- Commodity-linked notes (the idea is the same as in the previous case but underlying asset is the change of commodity prices);
- Interest-rate-linked notes that are connected to the movement in interesting rates.

The instruments being the objects of our investigation are close to the equity-linked notes but having as underlying stock a foreign exchange rate and the very important difference is that the structured notes of our concern do not offer any principal protection or guarantee principal.

McDonald (2013) mentions that the financial engineering is the consequence of Modigliani-Miller theorem. According to this famous theorem the value of a firm remains the same regardless of the structure of financing. Applying to derivative instruments it means that the value of the product doesn't change with any combination of its components. However we should remember the assumptions which Modigliani-Miller theorem based on: no frictions in the capital markets, no info asymmetry, no taxes, no bankruptcy costs, perfect competition (N. Andren,

2013). Thus in Miller-Modigliani world the structured note doesn't create any extra value for the investor but in the real world the financial instruments may have different taxation, transaction costs or regulatory etc. Financial engineering enables to take into account all these considerations and to create such product that suits the most to the investor.

With a glance to the above, Telpner (2004) calls the following benefits that structured products give to investors:

- The separation of different risks (e.g., market risk and credit risk);
- Investment diversification;
- Tax and regulatory benefits;
- Customization, i.e. structured notes may be constructed s.t. to satisfy the individual investor's preferences;
- Arbitrage.

However, the structured notes may be characterized by additional risk. In June 2011 Financial industry regulatory authority (FINRA) released the warning to the investors of structured notes describing drawbacks of those ones. They mentioned the following negative aspects of structured notes that can be not evident for an investor:

- Potential lack of liquidity as the investor may get the income if he holds the note until the maturity (it actually depends on the secondary market for these structured notes that can vary);
- The terms and structures of pay-out of the structured notes are usually more complex than in the case of traditional instruments that makes difficult for the investor to evaluate them;
- The structured notes can include some hidden or imputed costs that can be difficult for valuation (opportunity costs). As FINRA states, "The maximum return of any particular structured note with principal protection will typically reflect (and account for) the issuer's costs of manufacturing and maintaining the note as well as its own profit margin. These costs generally are not transparent to investors".

Sure the main consideration in this discussion is the lack of any guarantees for the capital protection, i.e. the investor's financial performance is defined by the exchange rate (USD/MXN) movement and doesn't have the upper or lower limits.

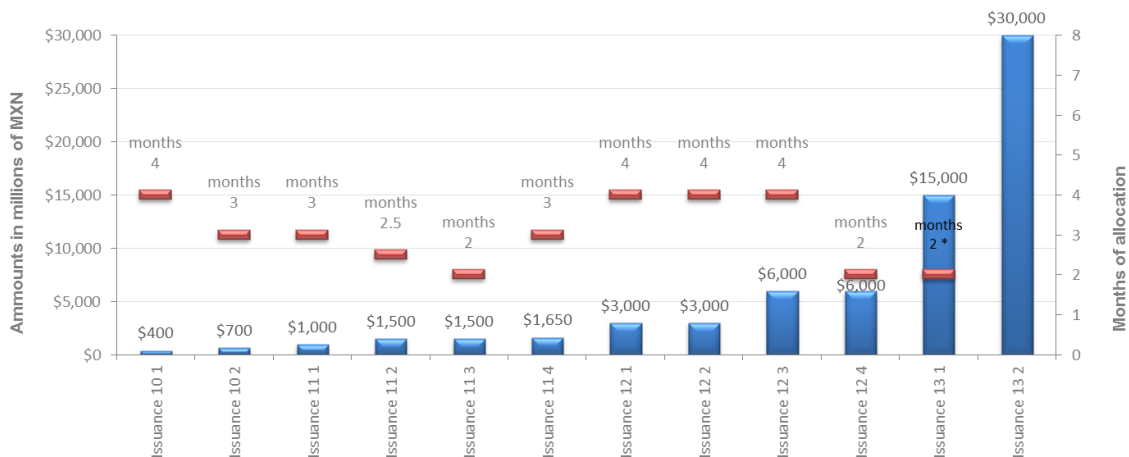
3. Background of the structure notes issued by the local bank in Mexico.

The Local Investment Bank started to issue Structured Notes without principal protection under the authorization of the Mexican regulatory supervisors⁵, on July 2010. The first issuance was for MXN 400 million and was allocated among 147 retail investors within 22 allocations during 4 months, with an average term of 28 days and average interest rates for allocations on MXN in a range of 9.5% to 14.5%, and for allocations on USD in a range of 5.7% to 10%.

3.1. Amounts of structured notes issued and period of allocation.

On the last years, the bank has continued issuing structured notes; increasing considerably the issued amount, from \$400 million pesos within the first issuance in 2010 to \$30 million pesos in the last issuance of our study in 2013, but it has remained the allocation period of each issuance within an average period of 3 months. (See Figure 1 below).

Figure 1. Structured Notes issued by the bank and their respective allocation period.



3.2. Rates offered in the structured notes issued and their equivalent return paid.

The highest rates offered by the structured notes compare with the Mexican and American risk free rates have reflected the risk of these investment instruments (See Figures 2 and 3 of Appendix A).

Figures 2 and 3 of Appendix A show the development of the average, maximum and minimum returns under MXN and USD Structured Notes issued from 2010 to 2012 and compare those rates with their respective risk free rates, showing that the majority of allocations have paid a return lower than the risk free rate.

⁵ The work presented in this paper is based in the information of the prospectus of Structure Notes issued by a Local Bank in Mexico, information that was collected by one of the writers of this thesis, as supervisor of the bank within the Financial supervisory authority in Mexico, Bank and Securities National Commission.

Also, according with Figures 4 and 5 below, the returns paid on most of the allocations of the structure notes were lower than the rates offered and some of them lost principal, especially under foreign exchange rate volatility periods.

Figure 4. Average rates allocated under MXN Structured Notes compare with the return paid and the pattern of the exchange rate at the allocation date.

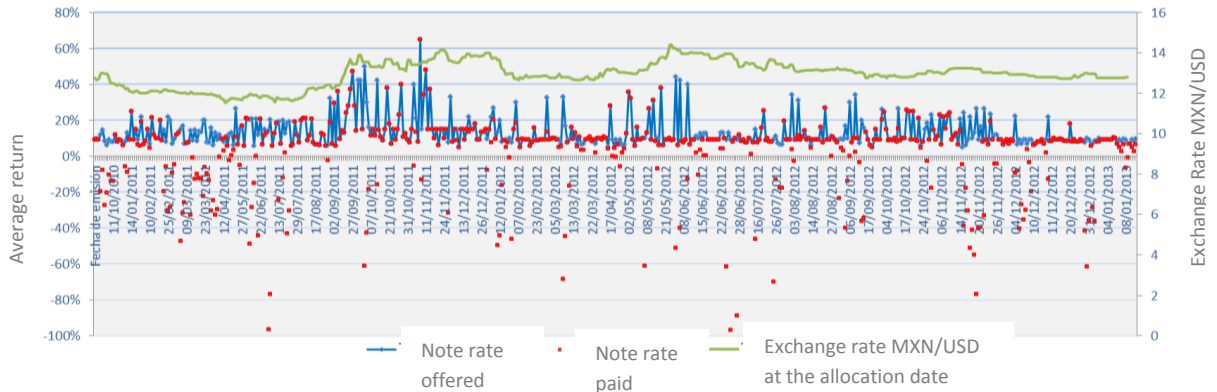
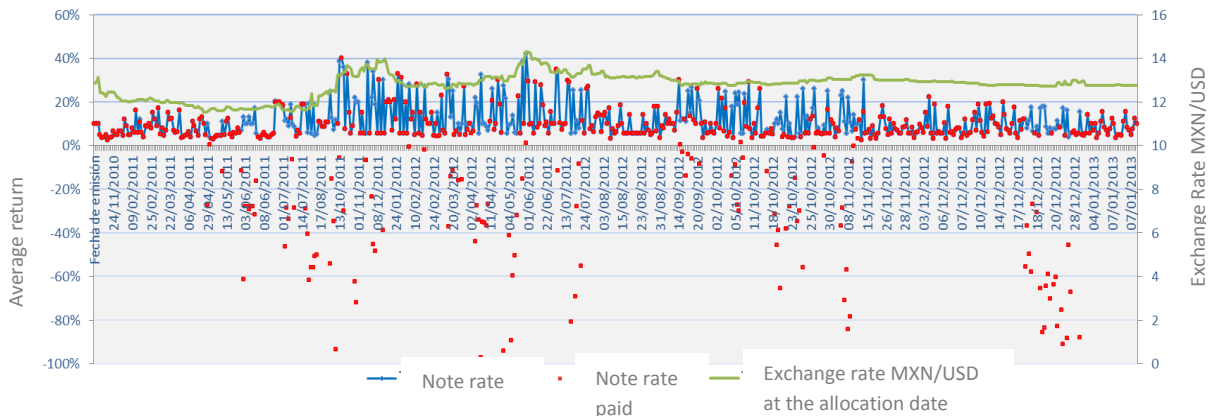


Figure 5. Average rates allocated under USD Structured Notes compare with the return paid and the pattern of the exchange rate at the allocation date.



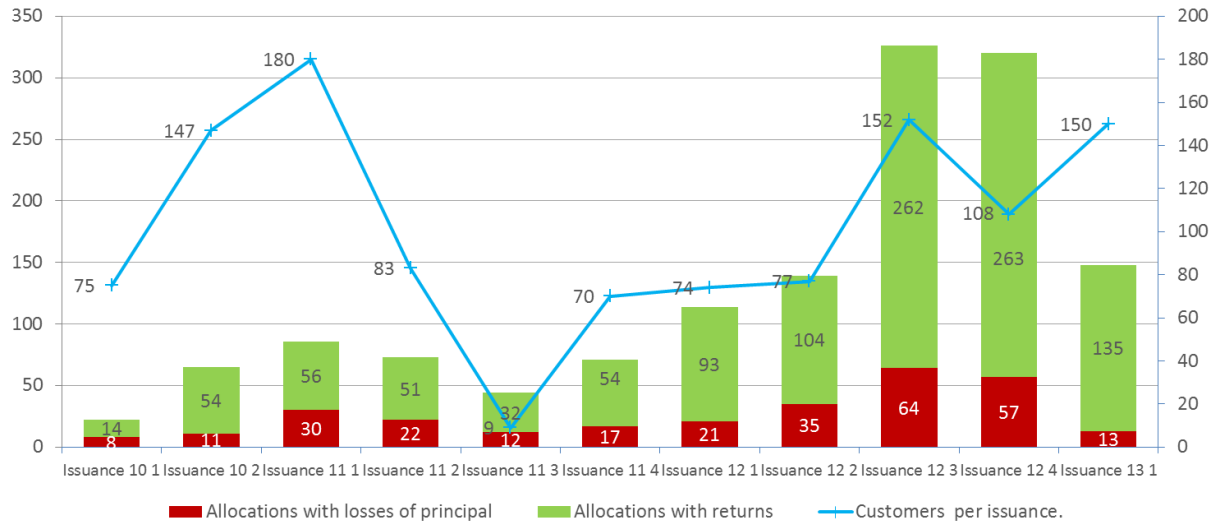
Similarly, we compared the highest rates offered by the local investment bank with the rates offered under similar structured notes issued in MXN or USD by an international bank⁶. See Figures 6 and 7 of Appendix A, which show that the rates offered by the international bank remained constant over the different allocations and were not higher than 10% for both the MXN and the USD allocations. However, in contrast the rates offered for the Local Bank did not show any pattern and were within a range from 4.5% to 65% for allocations in MXN and within a range from 1.6% to 42.25% for allocations in USD.

⁶ Due to the local bank confidential information law, we are going to omit the name of the international bank. However, as reference we will say that on 2013 it was one of the three biggest banks in Mexico considering the amount of assets.

3.3. Customers of the structured notes issued.

The low returns paid and the loss of principal of some allocations made some customers to stop investing in these products, occasioning that the number of investors dropped significantly in some issuances, as it is shown at the Figure 8 below.

Figure 8. Amount of investors and distribution of the allocations returns per issuance.



Furthermore, in the Table 1 of Appendix B, we show the number of allocations and the average amount invested in structured notes of the main customers of the Local investment bank. Where we can see that the main investors, as individuals, entities and financial institutions, used to renew their investments, as well as, the incorporation of new big investors in the last issuances.

The growth of the amount issued in the Structured Notes, the high and volatile rates offered by the local bank compare with an international bank, the loss of principal presented on most of the allocations and the decreasing of the customers in some issuances, take the attention of which financial instruments are integrating to the portfolio in order to offer high rates in the structured notes, as well as to the scheme how these notes are operating. Issues that will be analyze in the next section.

3.4. Types of structured notes issued by the local investment bank.

In order to determine the kind of structure notes that the local investment bank issued. We evaluate the maturity payment formula established in each allocation prospect, under different scenarios for the underlying asset. The result of the evaluation under different scenarios let us know which would be the possible returns and whether there would be possible to lose the principal or face amount invested.

Figures 9, 10, 11 and 12 in Appendix A show the main types of structured notes issued by the local investment bank and their possible gains and losses for the investor under different scenarios of the underlying asset, classifying those scenarios as good or bad, depending on the possibility to lose the principal invested. Also the diagrams of the profits showed in those figures, give an idea of the implicit derivative of each type of structured note: short call, short put, binary options and spread option.

The Table 2 below summarizes the main characteristics of the structured notes issued by the Local investment bank, based on figures 9, 10, 11 and 12 mentioned above: underlying asset, preservation of capital, derivative implicit, position on the underlying asset since the investor's and issuer's perspective, scenario of the asset price for a contingency since the investor's perspective and the position of the option implicit in each note.

Table 2. Summary with the characteristics of the options implicit in the structured notes issued.

Structure Note	Underlying asset	Preservation of capital	Implicit derivative position	Position respect to the underlying asset	Asset Price contingency	Profit diagram position
Dual in MXN	Foreign exchange rate	No	Short put	Long (buy)	<Strike K	
Dual in USD	Foreign exchange rate	No	Short call	Short (sell)	>Strike K	
Cake	Index	Yes	Binary option.	Long (buy) and short (sell).	< Strike K1 and > Strike K2	

Structure Note	Underlying asset	Preservation of capital	Implicit derivative position	Position respect to the underlying asset	Asset Price contingency	Profit diagram position
Range accrual	Foreign exchange rate	Yes	Spread option.	Long (buy)	< Strike K1 and > Strike K2	

From Table 2 above, we figure out that in the case of Dual structured notes, the fact that they do not preserve the principal is intrinsic in the position of the short call or put option, specifically when the underlying asset's price goes down under the strike price, in the case of a Dual structured note issued in MXN and when the underlying asset price goes up over the strike price, in the case of a Dual structured note issued in USD.

We identified that around 95% of the structured notes issued by the Local Investment Bank from 2010 to 2013 were those that do not preserve capital, i.e. of the types Dual in MXN and Dual in USD. This was the main reason to focus our paper on these structured notes and on the question whether the attractive rates offered by a local Investment Bank in Mexico under these products were plausible to get given the underlying asset prices distribution.

4. General description and operation of the Dual Structure Notes

Dual Structured Notes (Dual Notes), which general operative is illustrated in Figure 13 below, are short-term debt securities where the return (coupon and principal) is linked to the movements in prices of a foreign exchange rate, in our case MXN/USD.

Accordingly, the Dual Note is a fixed-income note with an embedded equity derivative. Investing in this note, from the investor's perspective, is the same as having a portfolio with a short call or short put option over an underlying asset (variable return) and at the same time placing a deposit with the note issuer (fixed return).

Figure 13. Dual Structured Note's diagram.

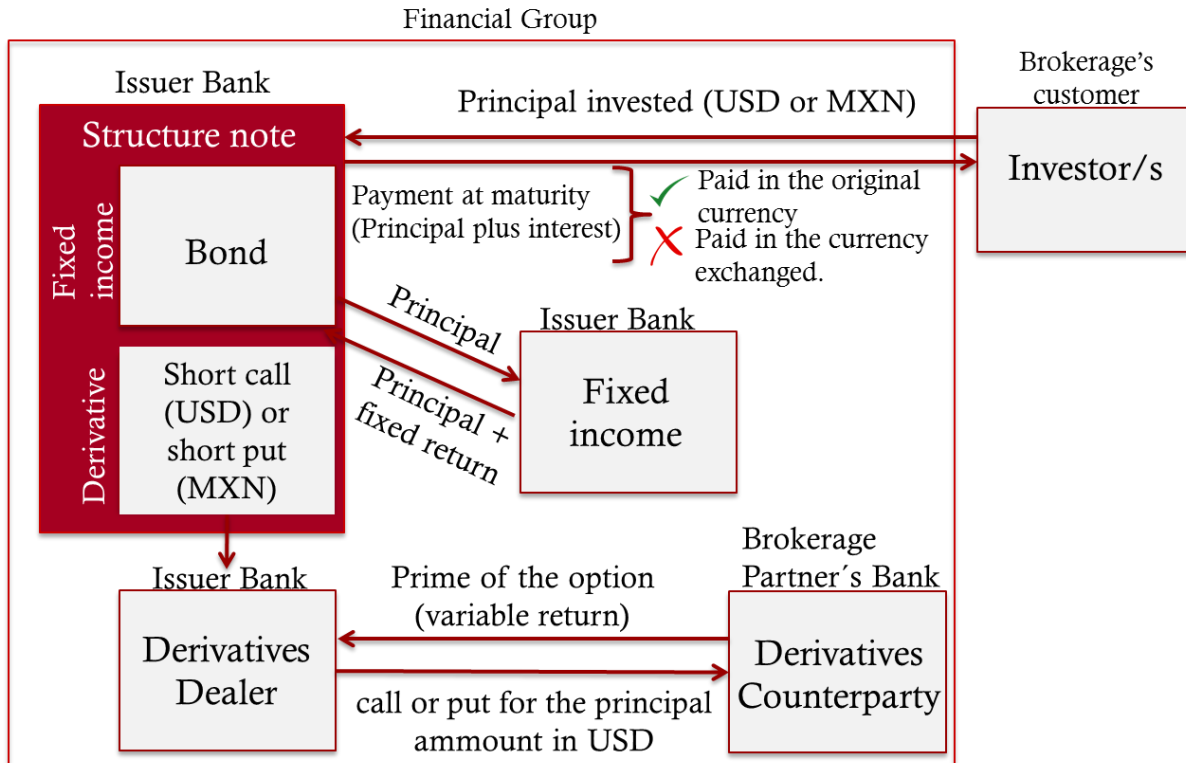


Figure 13 above shows that in the case of the Dual structured note issued by the Local investment bank in Mexico, at the issue date, the bank invests the principal received from the customers in a bond (fixed income) and sells an option (variable income) to its Brokerage's partner, getting a premium for selling the right of the Brokerage to exercise the option under a favorable position at the maturity date. The decision to exercise the option will determine whether the payment to the investor will be in the original currency (good scenario from the investor's perspectives) or will be exchanged to the other currency (bad scenario from the investor's perspective).

4.1. Description and operation of the Dual Structured Notes issued in MXN.

In the case of a Dual Note issued on Mexican Pesos (See Figure 14 below with information of the prospect and the valuation of the payment formula under different scenarios), the Issuer Bank structures it, investing the principal received from the investors in a corporate bond (fixed return) and writing a short put option (variable return). Also, see Figure 15 below with a diagram of how the bank operates the portfolio at the issue date to structure the note, in order to get the high returns offered in the notes.

Figure 14. Information of an allocation prospect for a Dual Structured Note issued in MXN.

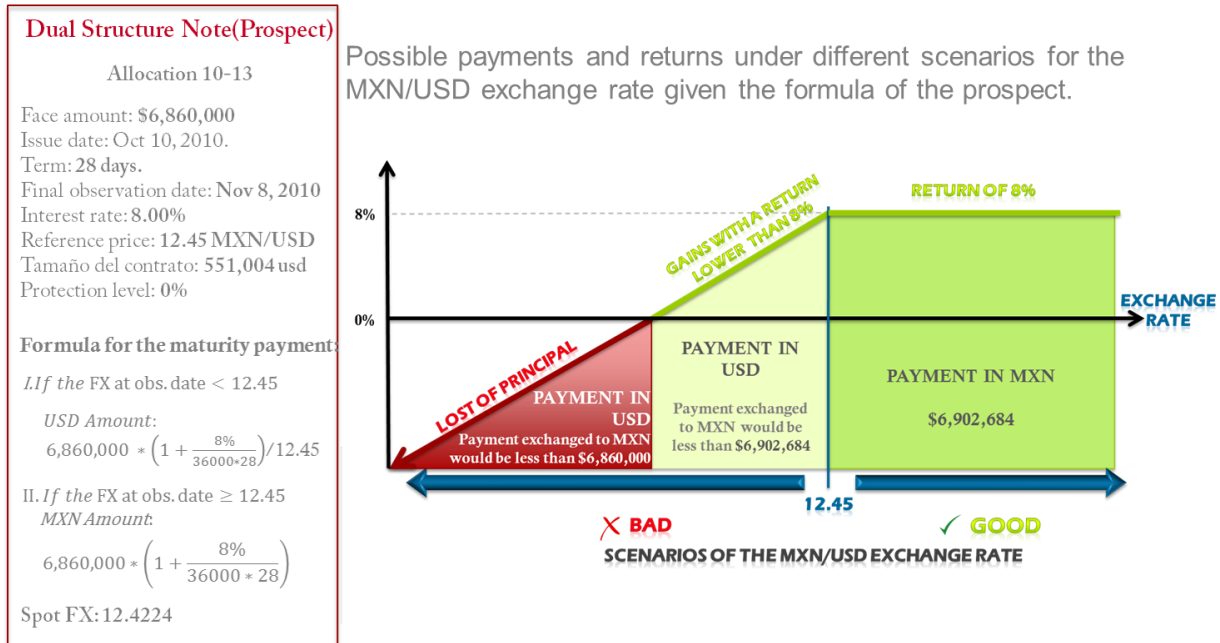
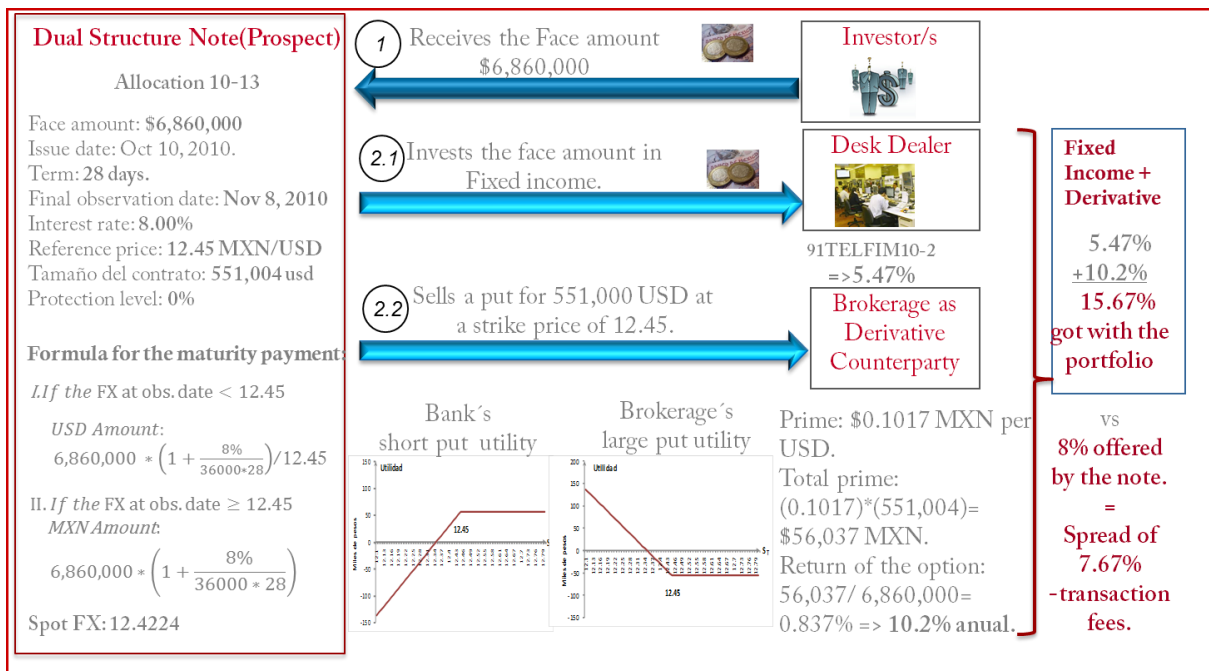


Figure 15. Portfolio at the issued date for an allocation of a Dual Structured Note in MXN.

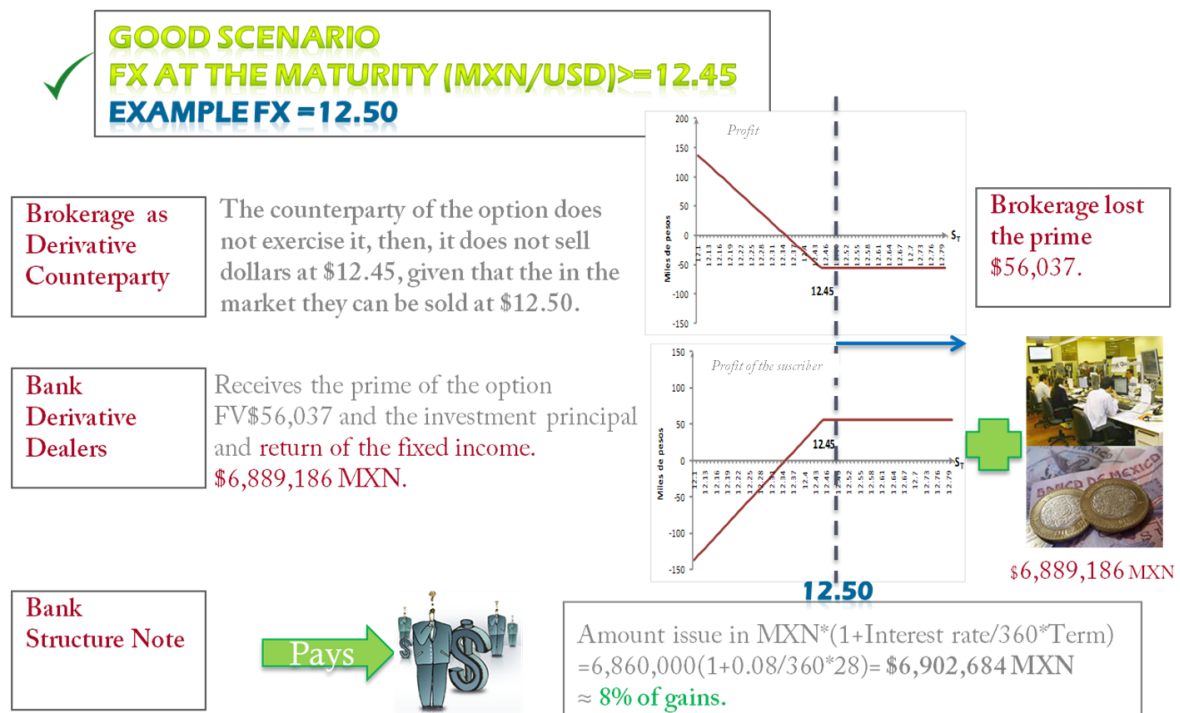


At the maturity date of the note, the variable return depends on the position of the underlying asset (FX price) compares with the option exercise price (FX of reference or strike of the option).

- Under a good scenario for investors, the FX price observed at the maturity should be equal or higher than the FX of reference, in order to receive the amount invested plus interest, on the original currency amount, in this case MXN. (See Figure 16 below with the effect on the portfolio at the maturity day under a good scenario).

➡ If we compare the amount in MXN obtained at the maturity date with the original amount invested in MXN, we are going to realize that the real return corresponds to the interest rate offered in the prospect of the note.

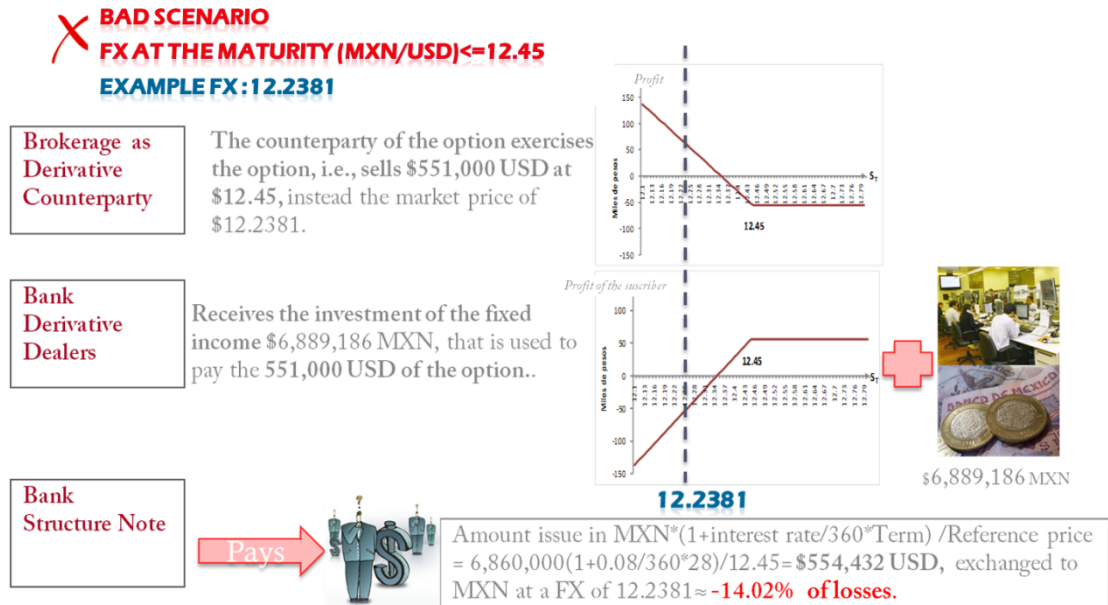
Figure 16. Portfolio at the maturity date for an allocation of a Dual Structured Note in MXN, under a good scenario from the investor's perspective.



- A bad scenario for the investors occurs when the FX price observed at the maturity date would be below the FX of reference. Then the note pays the return offered over the original face value in Mexican pesos (MXN) but exchanges it into Dollars (USD), using the FX of reference. (See Figure 17 below with the effect on the portfolio at the maturity day under a bad scenario).

➡ If we compare the amount in USD obtained at the maturity date valorized to MXN using the spot FX price of the maturity date, with the original amount invested in MXN, we are going to realize that the actual return would be a lower than the one offered in the prospect of the note or even more would represent a loss of principal.

Figure 17. Portfolio at the maturity date for an allocation of a Dual Structured Note in MXN, under a bad scenario from the investor's perspective.



4.2. Description and operation of the Dual Structured Notes issued in USD.

In the case of a Dual Note issued in Dollars (See Figure 18 below with information of the prospect and the valuation of the payment formula under different scenarios), the Issuer Bank structures it, investing the principal received from the investors in a corporate bond (fixed return) and writing a short call option (variable return). See Figure 19 below with a diagram of how the bank operates the portfolio at the issue date to structure the note, in order to get the high returns offered in the notes.

Figure 18. Information of an allocation prospect for a Dual Structured Note issued in USD.

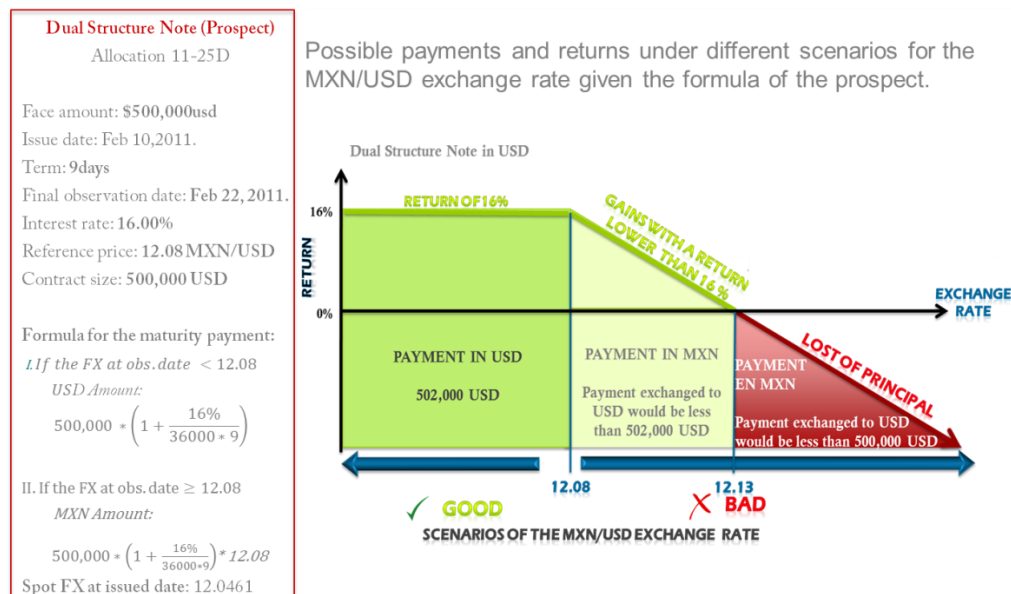
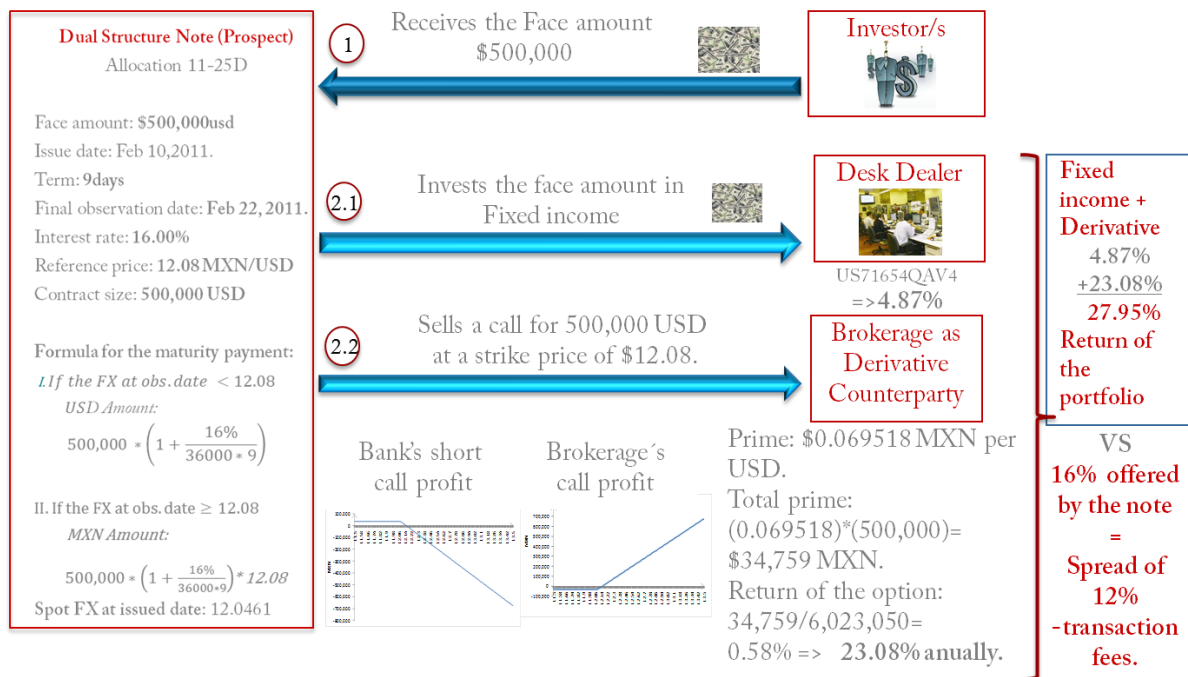


Figure 19. Portfolio at the issued date for an allocation of a Dual Structured Note in USD.

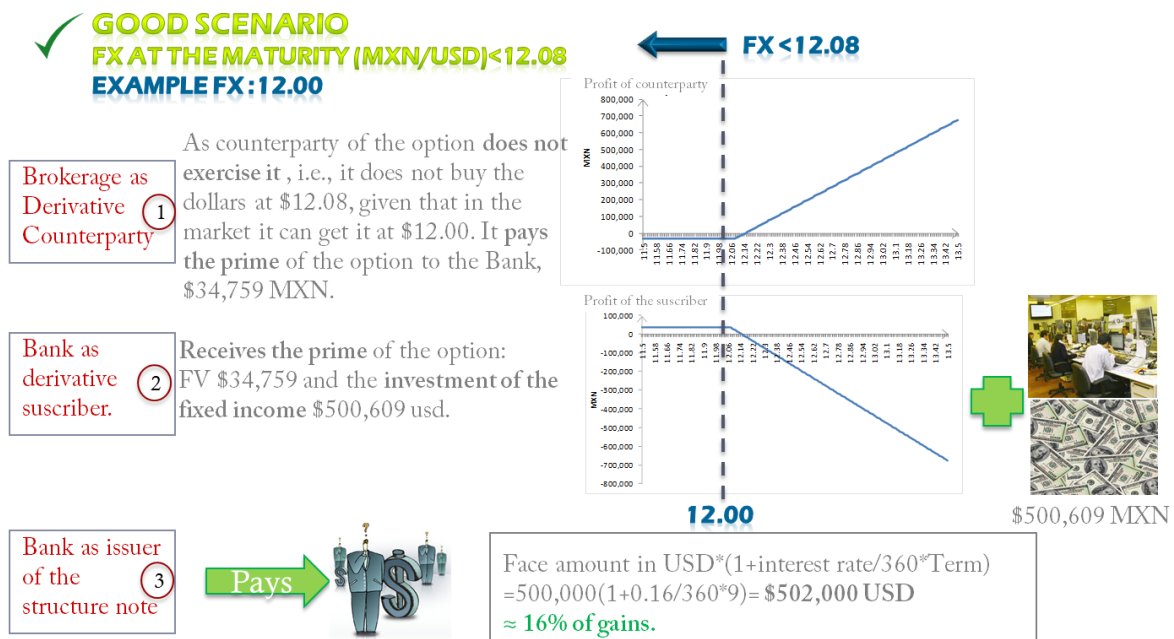


At the maturity date of the note, the variable return depends on the position of the underlying asset (FX price) compares with the option exercise price (FX of reference or strike of the option).

- Under a good scenario for investors, the FX price observed at the maturity should be equal or below the FX of reference, in order to receive the amount invested plus interest, on the original currency amount, in this case USD. (See Figure 20 below with the effect on the portfolio at the maturity day under a good scenario).

➔ If we compare the amount in USD obtained at the maturity date with the original amount invested in USD, we are going to realize that the actual return corresponds to the interest rate offered in the prospect of the note.

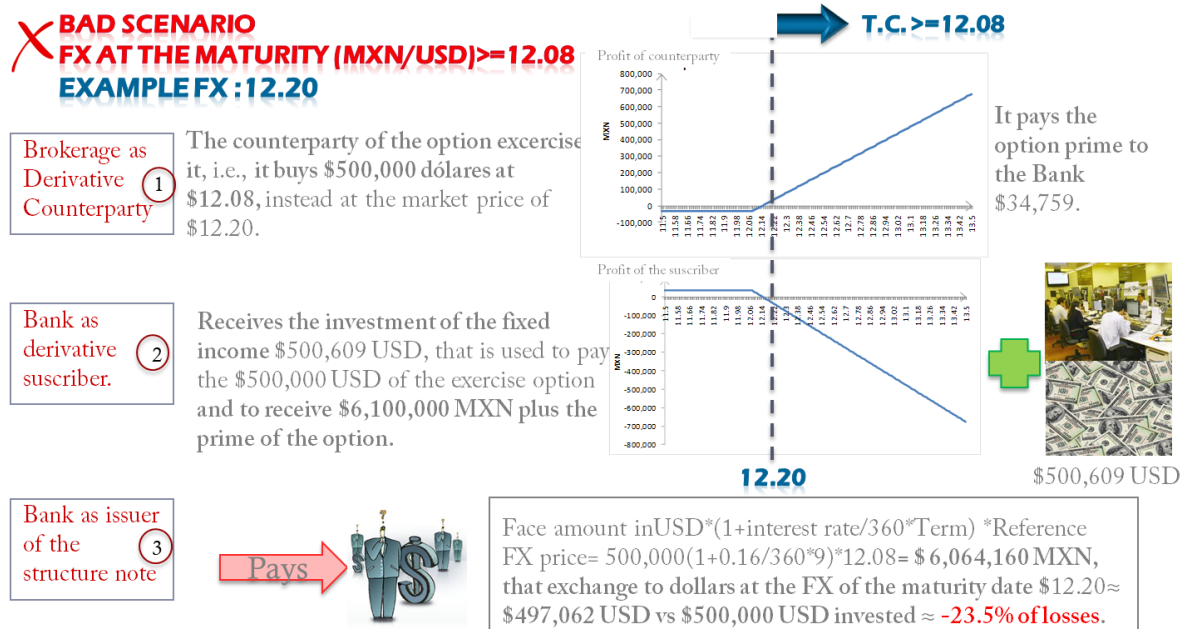
Figure 20. Portfolio at the maturity date for an allocation of a Dual Structured Note in USD, under a good scenario from the investor's perspective.



- A bad scenario for the investors occurs when the FX price observed at the maturity would be over the FX of reference. Then the note pays the return offered over the original face value in dollars (USD) but exchanges it into Mexican Pesos (MXN), using the FX of reference. (See Figure 21 below with the effect on the portfolio at the maturity day under a bad scenario).

➡ If we compare the amount in MXN obtained at the maturity date valorized to USD using the spot FX price of the maturity date, with the original amount invested in USD, we are going to realize that the actual return would be a lower than the one offered in the prospect of the note or even more would represent a loss of principal.

Figure 21. Portfolio at the maturity date for an allocation of a Dual Structured Note in USD, under a bad scenario from the investor's perspective.



4.3. Issues identified considering the Dual Structured Notes operation.

The fact that the rates offered by the Dual Structured Notes depend mainly on the premium of the written option and for instance on the strike used in the option, leads us to the next issues of our concern:

- Did the strikes used in the options written by the issuer bank are likely or probably to occur, given the term-ahead probability distribution of the foreign exchange rate? Or the strikes are chosen by the bank stochastically in order to get a high premium, aiming to issue a structured note that would let the bank offer high rates to the investors, but in the reality the notes could pay lower rates than those that were offered or could not preserve the principal invested, generating losses for the investors?
- Moreover, the fact that the counterparty or buyer of the options is the Brokerage House of the same financial group with the Investment Bank, requires us to determine whether the options embedded in the notes were operating at market prices, i.e., if they were sold at the expected prices within a confidence level in the term-ahead price FX distribution function.

Chapter 2: Method and Data

5. Method of research

As we showed above, the structured note includes two elements: zero-coupon bond and vanilla option. Estimating the bond return (fixed return of the note) we applied the approach offered by McDonald (2013) for a single payment bond.

5.1. Bond (fixed return)

A single payment bond is a financial instrument for which you pay today and that makes a single payment at time T (McDonald, 2013). The current price of single payment bond is defined by the following formulas:

$P(s) = e^{-r(T-t)}$ under a continuous interest rate basis (long term bonds).

$P(s) = \left(1 + \frac{r*t}{360}\right)$ under a simple interest rate basis (short term bonds).

Where P (s) – the current price of bond;

r - the annual continuously compounded interest rate or the annual simple interest rate.;

T – time of maturity;

t – time of purchasing.

5.2. Payoffs and profits for the options (variable return)

More difficult is to define pay-offs of the derivative part. It actually represents the vanilla option. The detailed description of options, kind of options, their terminology and strategies is given by McDonald (2013). To give the complete guide to the option theory is beyond the scope of this work but we adduce here the general idea of option pay-offs and profits.

For the European call option the pay-off is expressed by following:

Call pay-off = max [0; spot price at maturity – strike price of option].

The European call option profit then is equal to call pay-off – future value of option premium (i.e. the price of option discounted to the future moment of maturity).

The clear example of this point is given by McDonald (2013) in the table 2.3, p. 38 which uses the case of European call option on the S&R index. See Figure 22 of Appendix A.

The above concerns the buyer of option or in other words the long position in the option. For the seller or the short position the pay-off and profit will transform the following way:

Pay-off = -max [0; spot price at maturity – strike price of option]

Profit = -max [0; spot price at maturity – strike price of option] + future value of option premium.

So as we may see from the formulas the maximum profit for the call option seller is equal to the future value of option premium.

Let's now observe the case of put option. Understanding what the put is, it is evident that the pay-off for the put option is opposite to the one of the call:

$$\text{Pay-off} = \max [0; \text{strike price} - \text{spot price at maturity}].$$

Analogically the profit for the put can be defined by the next expression:

$$\text{Profit} = \max [0; \text{strike price} - \text{spot price at maturity}] - \text{future value of option premium}.$$

It may be illustrated with the figure 23 of Appendix A (we use the same figures as in the example with the call option).

The similar way as in the case of call option, the short put option can be easily derived from the long position:

$$\text{Pay-off} = -\max [0; \text{strike price} - \text{spot price at maturity}]$$

$$\text{Profit} = -\max [0; \text{strike price} - \text{spot price at maturity}] + \text{future value of option premium}.$$

5.3. Critical FX prices estimation.

Thus we have identified the implicit options in the Dual structured notes according with sections 4.1 and 4.2, a short call for allocations issued in USD and a short put for allocations issued in MXN. Then we follow the next steps to determine whether the strikes used in the options are likely to occur, estimating critical exchange rate prices in the left or right tail of the term-ahead distribution, using the approach to estimate the lognormal critical prices given by Dowd (2002, ch. 3) and afterwards compare those values with the strike used in the option issued:

1. Calculate log-differences of the daily FX prices, given that it is well known that the log-differences (log-returns) are normally distributed.

$$\ln FX - \ln \overline{FX} \sim N(\mu, \sigma)$$

2. For a long position in the asset (position for the short put implicit in the Dual note issued in MXN), estimate the critical FX price in the left tail of the h-day ahead FX price distribution given by the 5% quantile, with the next formula:

$$\text{Down critical FX} = FX_{down}^* = \overline{FX} * e^{(h * \mu + \sqrt{h} * \sigma * Z(1 - \alpha))} \text{ (for the left tail of exchange rate distribution),}$$

- For a short position in the asset, (position for the short call implicit in the Dual note issued in USD), estimate the critical FX price in the left tail of the h-day ahead FX price distribution given by the 95% quantile, with the next formula:

Up critical FX = $FX_{up}^* = \overline{FX} * e^{(h * \mu + \sqrt{h} * \sigma * Z(\alpha))}$ (for the right tail of exchange rate distribution),

Where *critical FX* – the critical exchange rate price;

\overline{FX} – the spot exchange rate price at the issue date ;

h – the time horizon, that in our case will be the same as the term of the option, in order to determine the term-ahead distribution;

μ - the daily mean; calculated as the average of the last n log returns before the issue date.

σ – the daily standard deviation; calculated over the last n log returns observed before the issue date.

$Z(\alpha)$ and $Z(1 - \alpha)$ – the quantile of distribution with the chosen level of confidence (we use $\alpha = 0,95$).

5.4. Options pricing and VaR.

Given the estimates of the critical FX prices in the left or right tail of distribution and that the risk of the structured notes is of our concern, we are going to estimate the value-at-risk (VaR) for the options implicit in the Dual structured notes.

The definition of VaR is given by Dowd (2002, ch. 2). “In its most literal sense, VaR refers to a particular *amount of money*, the maximum amount we are likely to lose over some period, at a specific confidence level”. We may put it mathematically as the following:

$$VaR_{\alpha}(L) = \min (l: \Pr (L > l) \leq 1 - \alpha,$$

Where L – the future portfolio loss,

α – the confidence level. We will use the confidence level equal to 0,95.

The VaR concept has its attraction to apply. This stems from several ideas which are explained by Dowd (2002, ch. 2).

- The first advantage is that VaR provides a common consistent measure of risk across different positions and risk factors. It can take into account different kinds of assets and can be applied to estimate currency options in our case as well.

2. The other point is that it takes account of the correlations between different risk factors. As well as the simplicity of the VaR in monetary terms, possibility of risk aggregation and probabilistic character of the estimator.

Developing the research we are going to apply then the method of estimating Value-at-Risk of options by the *Black-Scholes theoretical model*, guided by Dowd (2002, ch. 5) and by lecture notes (Nilsson, 2014). Lets observe the main steps of the estimation.

To compute the option price with this approach the famous Black-Scholes formula is applicable, Hull (2000, ch. 13.8). For call and put options respectively the formulas will be the following:

$$c = S * N(d1) - K * e^{-r_f * T} * N(d2),$$

$$p = K * e^{-r_f * T} * N(-d2) - S * N(-d1),$$

$$\text{Where } d1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r_f + \frac{\sigma^2}{2}\right) * T}{\sigma * \sqrt{T}},$$

$$d2 = d1 - \sigma * \sqrt{T},$$

c and p – prices for call and put options respectively,

S – current stock price,

N – normal distribution,

K – strike price of the option,

r_f – risk-free rate,

T – time to maturity.

The Black-Scholes formula is applied in the case of stock options. As we have here the currency option we need to transform a little bit the formula. This is called the Garman-Kohlhagen model, Hull (2000, ch. 15.5), and is shown below (for dollar-denominated option):

$$c = \overline{FX} * e^{-r_m * T} * N(d1) - K * e^{-r_u * T} * N(d2),$$

Where r_m – peso-denominated interest rate,

r_u - the dollar interest rate.

$$d1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r_m - r_u + \frac{\sigma^2}{2}\right) * T}{\sigma * \sqrt{T}},$$

$$d2 = d1 - \sigma * \sqrt{T},$$

The price for put option is defined by put-call parity:

$$P = C + K * e^{-r_u * T} - \overline{FX} * e^{-r_m * T}$$

We use the formulas above to calculate option prices for the current exchange rate price. Due that the critical exchange rate prices were estimated considering the holding period equal to the term of the options, the price of the option at the maturity date will correspond to the payoffs of the options at the critical prices estimated. Then value-at-risk for short call and put options is defined by formulas:

$$\text{VaR}_{\alpha}^{\text{short call}} = \text{Payoff call (FX}^*) - c(\overline{\text{FX}}) = \max(0, \text{FX}^* - K) - c(\overline{\text{FX}})$$

$$\text{VaR}_{\alpha}^{\text{short put}} = \text{Payoff put (FX}^*) - p(\overline{\text{FX}}) = \max(0, K - \text{FX}^*) - p(\overline{\text{FX}})$$

Where,

Payoff call (FX*) and Payoff put (FX*) - call and put option payoffs for the critical exchange rate price respectively.

$c(\overline{\text{FX}})$, $p(\overline{\text{FX}})$ - call and put option prices at the current exchange rate price respectively.

6. Data

The base of our research consists of information of the prospects of 438 Dual structured notes in MXN allocated by a Local Investment Bank in Mexico from July 2010 to January 2013 and 1,024 Dual structured notes in USD allocated from July 2010 to June 2013. This information was collected by one of the writers of this paper as supervisor regulator in Mexico during the same period.

The main characteristics of the collected structured notes were: Face amount, Currency of the allocation, Term, Date of the issuance, Date of maturity, Percentage of preservation of capital, Rate issued, Description of underlying asset, Underlying strike, Date of reference for the underlying asset value, Spot price of the underlying asset at the issue date, Final price of the underlying asset at the maturity date, Formula for the payment of the note, Payment at the maturity and Number of customers per allocation and Amount invested per customer.

Secondly, we used the next data series of the factors needed to calculate the critical FX price values and the price of the options implicit in the structure notes:

- *Daily exchange rates to pay obligations entered into in U.S. dollars payable in México*⁷, from January 2009 to June 2013. <http://www.banxico.org.mx/portal-mercado-cambiarior/foreign-exchange-markets--exc.html>

- *Daily curve zero coupon bonds denominated in pesos* issued by the Mexican Government⁸ (28 days Cetes nominal interest rates expressed in annual percent), from July 2010 to July 2013, with their respective interpolated rates from 1 to 91 days, in which period were situated the term of the structured notes.
<http://www.banxico.org.mx/SieInternet/consultarDirectorioInternetAction.do?accion=consultarCuadro&idCuadro=CF107§or=22&locale=en>
- *Daily Treasury Yield Curve Rates of the United States of America*⁹, from July 2010 to July 2013, with their respective interpolated rates from 1 to 91 days, in which period were situated the term of the structured notes. <http://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yield>
- *Implicit volatility in the vanilla put options* traded in Mexico over the foreign exchange rate MXN/USD, from July 2010 to July 2013, in order to compare with the standard deviation used to calculate the price of the options implicit in the notes and the critical FX values, getting that they were similar. <http://www.valmer.com.mx/en/>

⁷ The exchange rate (FIX) is determined by Banco de Mexico as an average of quotes in the wholesale foreign exchange market for operations payable in 48 hours. Banco de México informs the FIX from 12 o'clock onwards each banking day. It is published in the Official Gazette (Diario Oficial de la Federación) one banking business day after its determination date, and is used to settle liabilities denominated in U.S. dollars payable in Mexico on the day after its publication in the Official Gazette.

⁸ Zero coupon bonds denominated in pesos issued by the Mexican Government. For further information see the provisions issued in the Official Gazette of November 28, 1977 and of July 8, 1993.

⁹ Daily Treasury Yield Curve Rates relates the yield on a security to its time to maturity is based on the closing market bid yields on actively traded Treasury securities in the over-the-counter market. These market yields are calculated from composites of quotations obtained by the Federal Reserve Bank of New York.

Chapter 3: Results

7. Results

We are going to use the data of the Dual structured note in MXN and in USD; exemplified in the sections 4.1 and 4.2, to show how to estimate the critical foreign exchange prices and compare them with the strike used in the option implicit in each note, in order to determine whether the strike used in the options were likely to occur given the term-ahead distribution of the foreign exchange rate price.

Moreover, in order to determine whether the implicit options in the structured notes, were sold to its brokerage partner at market prices. We are going to get the price of the options with the Garman-Kohlhagen model using the original FX price strike and compare it with the price using as strike the critical FX prices estimated. This will show if the options were sold at an expected price, according with the definition of market value presented in the Introduction.

7.1. Dual Structured Note in MXN results.

Table 3. Results of the Critical FX prices, option prices and VaR for a Dual in MXN.

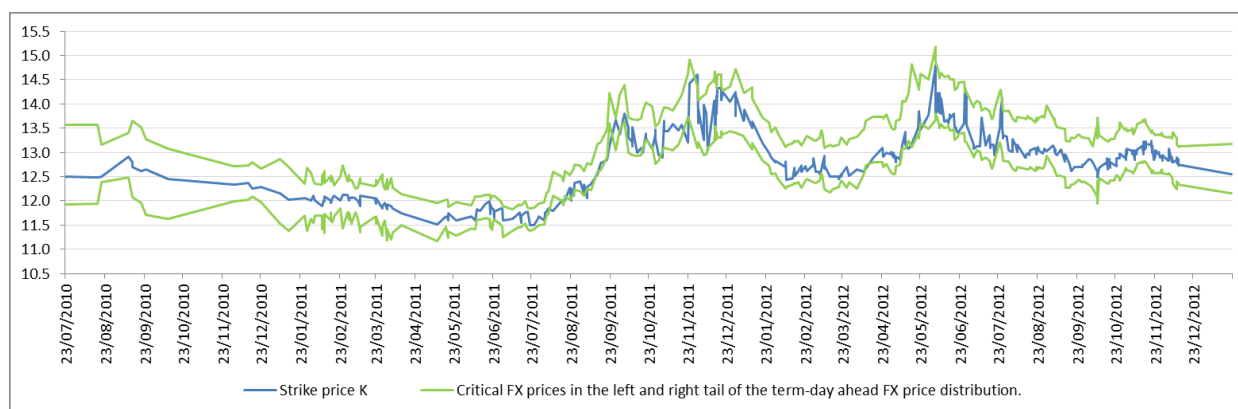
Data of the structure note and parameters estimated		
	Issue date (test day)	11/10/2010
\overline{FX}	Current Foreign exchange rate.	12.42
K	Strike price (reference price)	12.45
T	Time to maturity (days)	28
r_m	Mexican risk free rate rf (pear year)	0.04180
r_u	Foreign exchange rate (per year)	0.00001
μ	Expected Foreign exchange return (daily)	-0.00025
σ	Foreign exchange return volatility (daily)	0.00673
h	Holding period h (days)= In this case will be equal to the term	28
$\mu * h$	Expected Foreign exchange return (scalated to the holding period)	-0.00689
$\sigma\sqrt{h}$	Foreign exchange return volatility (scalated to the holding period)	0.03563
α	Alpha	0.95
Critical values estimated		
FX_{down}^*	Critical FX price in the left tail of the term-day ahead FX price distribution given by the 5%-quantile.	11.63
FX_{up}^*	Critical FX price in the right tail of the term-day ahead FX price distribution given by the 95%-quantile.	13.08
Option prices valuated at the original strike or the critical FX value as strike, using the Black and Sholes formula.		
	$put\left(\overline{FX}, FX_{down}^*, T/252, r_m, r_u, \sigma\sqrt{252}\right)$	0.0039
	$put\left(\overline{FX}, FX_{up}^*, T/252, r_m, r_u, \sigma\sqrt{252}\right)$	0.6185
	$put\left(\overline{FX}, K, T/252, r_m, r_u, \sigma\sqrt{252}\right)$	0.1617

Payoff of the put option, using the critical FX estimated as current price.		
	$Max(0, K - FX_{down}^*)$	0.8152
	$Max(0, K - FX_{up}^*)$	0.0000
VaR for the short put option implicit in the Dual structure note		
	VaR at the 95%-level for the short put option. $Max(0, K - FX_{down}^*) - put(\overline{FX}, K, T/252, r_m, r_u, \sigma\sqrt{252})$	0.6534

We could appreciate that the strike K used in the option implicit in the structured note, was situated within the interval (FX_{down}^*, FX_{up}^*) , i.e., $12.45 \in (11.63, 13.08)$. Situation that showed that the rate offered by the structured note was likely to occur, given that the strike used to price the option and get the premium, was situated within the range of the Critical FX prices in the right and left tail of the term-day ahead FX price distribution given by the 5% and 95%-quantile.

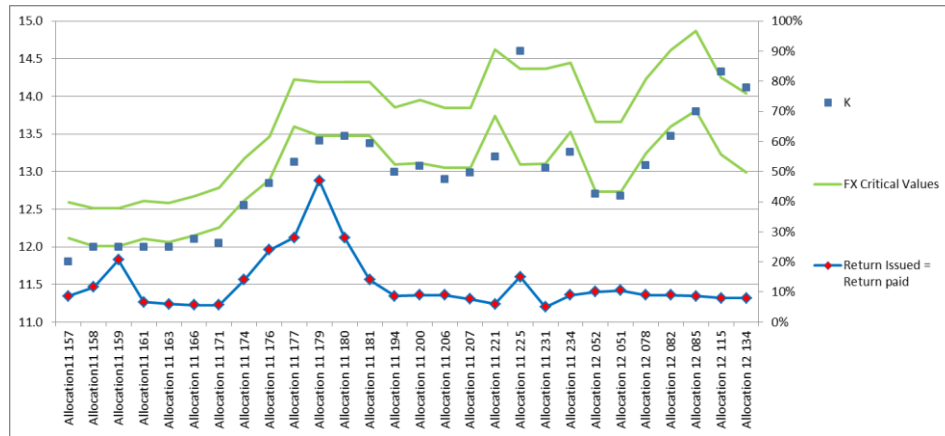
We repeated the calculations above for all the sample of Dual structured notes in MXN, getting their respective critical FX prices and comparing them with the strike price used in the respective note. The results are shown in the Figure 24.

Figure 24. Comparison among the strike of each Dual Structured Note in MXN of the sample, compare with their respective Critical FX prices in the right and left tail of the term-day ahead FX price distribution.



We found 28 allocations of 438 Dual structured notes in MXN, which strikes were outside the critical FX prices estimated, in specific much lower than the critical price value FX_{down}^* (See figure 25 below). According with their characteristics, the 28 notes were allocated offering an average term of 7 days and rates among 5% and 47%, which were totally paid at the maturity day.

Figure 25. Strikes outside the probabilistic confidence interval and returns paid for notes issued in MXN.

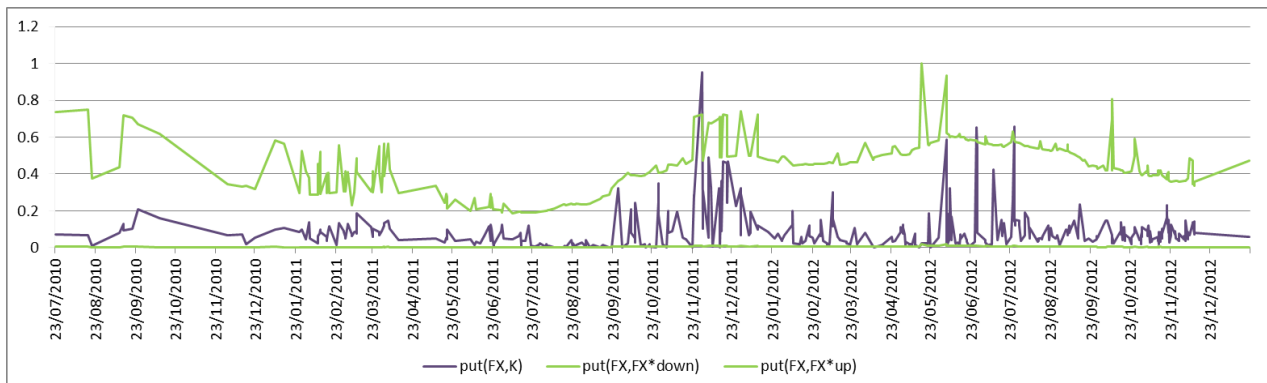


This situation makes to think that even that the strikes were not likely to occur, the bank can give some certainty about the return that would pay to the investors under Dual Structured Notes in MXN, subscribing options implicit in the notes with a low strike that increases the possibilities of a good scenario for the investors.

The flexibility that the bank has to sell expensive options to its Brokerage partner as counterparty lets it pay high rates to the investors under Dual structured notes in MXN. This is the base to show whether the options operating between both entities as part of a Financial Group were operated at market prices.

Then, valuing the options of the 438 Dual structured notes in MXN at the original strikes and comparing it with the option prices at the critical FX prices (See Figure 26 below), we detect that for the 28 structured notes previous referred, their option prices were outside the range of the option valued at the critical values. This can be interpreted as that those options were not operated at market prices.

Figure 26. Comparison among the price of the option implicit in each Dual Structured Note in MXN of the sample, valued at the original strike and with strikes changed for the critical FX prices in the right and left tail of the term-day ahead FX price distribution.



By the other hand, even that the results showed that for the rest of allocations, the strike prices of the implicit options in the notes were likely to occur, the information of the payments of these Dual structured notes in MXN showed that 108 of 428 allocations (25%) lost principal, due to a bad scenario for the position in the short put option implicit in the note. This was the reason to calculate the VaR for the short put option, as a tool for investors to take investment decisions according with their investment profile and to help them to realize the implicit risk in this kind of instruments.

According with the calculations, the VaR at the 95%-level for the short put option is \$0.6534 MXN. This can be interpreted as that the probability of a future short put option loss will be larger than the VaR=\$0.6534 MXN is 5%.

We can express the VaR in terms of percentage losses, in the next way:

$$\frac{VaR * (Size\ of\ the\ portfolio)}{Face\ amount} = \$0.6534\ MXN * \frac{\left(\frac{\$6,860,000\ MXN}{\$12.45\ MXN/USD} \right)}{\$6,860,000\ MXN}$$

$$= \$0.6534\ MXN * \frac{(\$554,000\ USD)}{\$6,860,000\ MXN} = 67\%$$

This can be interpreted as that the probability of a future short put option loss percentage will be larger than the VaR=67%, is 5%.

7.2. Dual Structured Note in USD results.

Table 4. Results of the Critical FX prices, option prices and VaR for a Dual in USD.

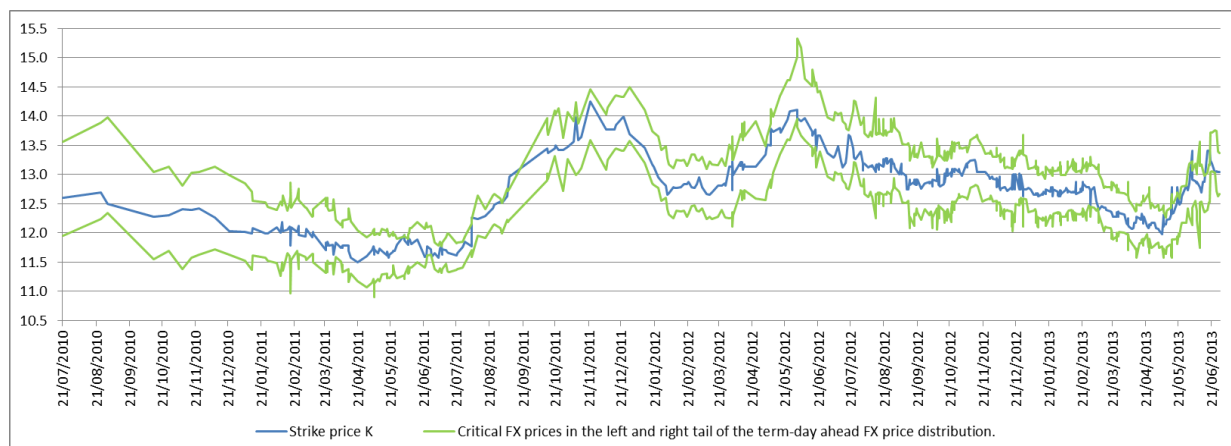
Data of the structure note and parameters estimated		
	Issue date (test day)	14/02/2011
\bar{FX}	Current Foreign exchange rate.	12.05
K	Strike price (reference price)	12.06
T	Time to maturity (days)	9
r_m	Mexican risk free rate rf (pear year)	0.04059
r_u	Foreign exchange rate (per year)	0.00001
μ	Expected Foreign exchange return (daily)	-0.00027
σ	Foreign exchange return volatility (daily)	0.00614
h	Holding period h (days)= In this case will be equal to the term	9
$\mu * h$	Expected Foreign exchange return (scalated to the holding period)	-0.00244
$\sigma\sqrt{h}$	Foreign exchange return volatility (scalated to the holding period)	0.01842
α	Alpha	0.95

Critical values estimated		
FX_{down}^*	Critical FX return in the left tail of the term-day ahead FX price distribution given by the 5%-quantile.	11.66
FX_{up}^*	Critical FX return in the right tail of the term-day ahead FX price distribution given by the 95%-quantile.	12.39
Option prices valuated at the original strike or the critical FX value as strike, using the Black and Sholes formula.		
	$call(\overline{FX}, FX_{down}^*, T/252, r_m, r_u, \sigma\sqrt{252})$	0.4077
	$call(\overline{FX}, FX_{up}^*, T/252, r_m, r_u, \sigma\sqrt{252})$	0.0076
	$call(\overline{FX}, K, T/252, r_m, r_u, \sigma\sqrt{252})$	0.0924
Payoff of the call option, using the critical FX estimated as current price.		
	$Max(0, FX_{down}^* - K)$	0.0000
	$Max(0, FX_{up}^* - K)$	0.3307
VaR for the short call option implicit in the Dual structure note		
	VaR at the 95%-level for the call option. $Max(0, FX_{up}^* - K) - call(\overline{FX}, K, T/252, r_m, r_u, \sigma\sqrt{252})$	0.2382

We could appreciate that the strike K used in the option implicit in the structured note, was situated within the interval (FX_{down}^*, FX_{up}^*) , i.e., $12.06 \in (11.66, 12.39)$. Situation that showed that the rate offered by the structured note was likely to occur, given that the strike used to price the option and get the premium, was situated within the range of the Critical FX prices in the right and left tail of the term-day ahead FX price distribution given by the 5% and 95%-quantile.

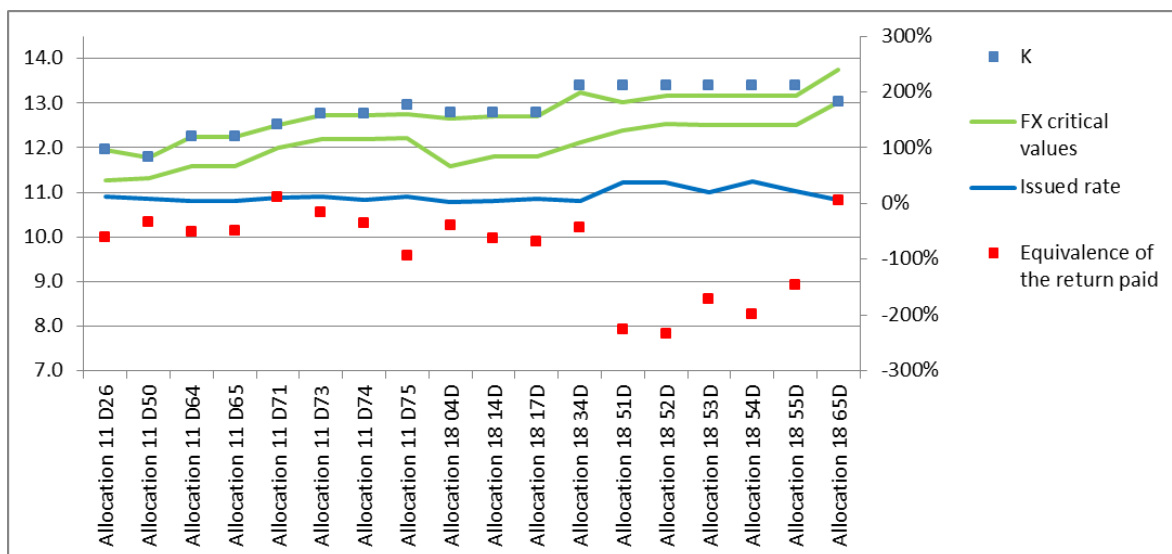
We repeated the calculations above for all the sample of Dual structured notes in USD, getting their respective critical FX prices and comparing them with the strike price used in the respective note. The results are shown in the Figure 27 below.

Figure 27. Comparison among the strike of each Dual Structured Note in USD of the sample, compare with their respective Critical FX prices in the right and left tail of the term-day ahead FX price distribution.



We found 18 allocations of 1024 Dual structured notes in MXN, which strikes were outside the critical FX prices estimated, in specific much higher than the critical price value FX_{up}^* (See Figure 28 below). According with their characteristics, the 18 notes were allocated offering terms of 7, 14 and 21 days and rates among 3.5% and 38% and all of them presented losses of capital at the maturity date.

Figure 28. Strikes outside the probabilistic confidence interval and returns paid for notes issued in USD.

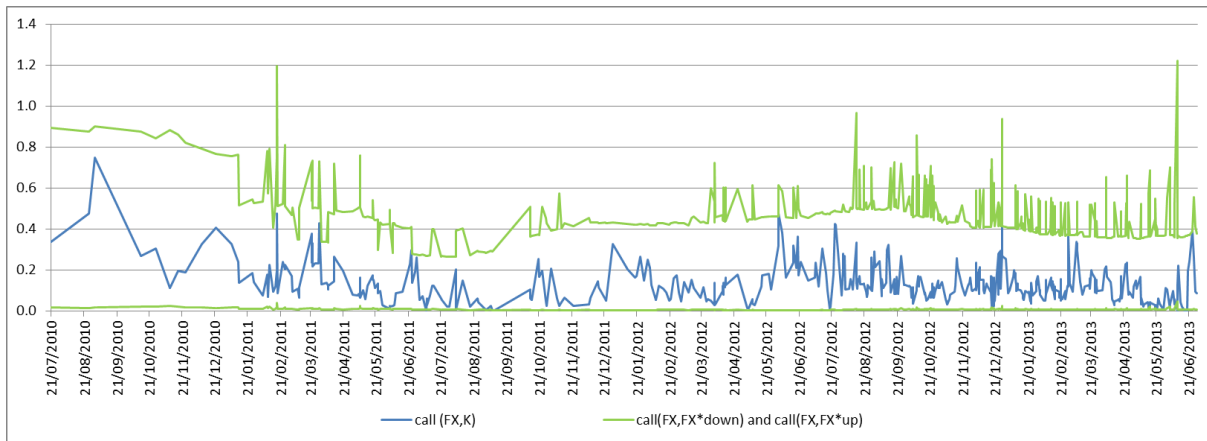


This situation makes to think that even that the strikes were not likely to occur, the bank could know with some certainty that the returns that it offered in the structured notes were not very plausible to pay to the investors. In some manner we can say that the bank could subscribe a high strike in the put option that let it offered a high return in the Dual note in USD issued, but with a high possibility of a bad scenario for the investors.

The flexibility that the bank has to sell expensive options to its Brokerage partner as counterparty lets it offer high rates to the investors, even if they are not plausible to pay according with the term-ahead distribution of the FX price. This is the base to show whether the options operating between both entities as part of a Financial Group were operated on market prices.

Then, valuing the options of the 1024 Dual structured notes in USD at the original strikes and comparing it with the option prices at the critical FX prices (See Figure 29 below), we detect that for the 18 structured notes previous referred, the option prices were outside the range of the option valuated at the critical strike values. This can be interpreted as that those options were not operated at market prices.

Figure 29. Comparison among the price of the option implicit in each Dual Structured Note in USD of the sample, valuated at the original strike and with strikes changed for the critical FX prices in the right and left tail of the term-day ahead FX price distribution.



By the other hand, even that the results showed that for the rest of allocations the strike prices at which the implicit options in the notes were likely to occur, the information of the payments of these Dual structured notes in USD showed that 236 of 1024 allocations (23%) have lost principal, due to a bad scenario for the position in the short call option implicit in the note. This was the reason to calculate the VaR for the short call option, as a tool for investors that help them to take investment decisions according with their investment profile and to realize the implicit risk of this kind of instruments.

According with the computing, the VaR at the 95%-level for the short call option calculated was \$0.2382 MXN. This can be interpreted as that the probability of a future option loss will be larger than the VaR=\$0.2382 MXN is 5%.

We can express the VaR in terms of percentage losses, in the next way:

$$\begin{aligned} & \frac{VaR * (Face\ amount)}{Face\ amount * Spot\ price\ at\ issue\ date} \\ &= \$0.2382\ MXN * \frac{500,000\ USD}{(500,000USD * 12.0461MXN/USD)} \\ &= \$0.2382\ MXN * \frac{(\$554,000\ USD)}{\$6,860,000\ MXN} = 67\% \end{aligned}$$

This can be interpreted as that the probability of a future portfolio loss percentage will be larger than the VaR=67%, is 5%.

8. Conclusion

We determined that most of the options implicit in the Dual Structured Notes issued in MXN or USD from July 2010 to June 2013, by the Local Investment Bank in Mexico, were operated at market prices. Also, we found that the respective strikes of the options embedded in the notes were chosen within the critical prices for the exchange rate (MXN/USD) term-ahead distribution prices.

However, we found some allocations of structured notes which the strike used in the implicit option were far from the critical values calculated for. As bank was aiming to pay good returns for a minority of investors in the case of Dual structured notes issued in MXN and to attract new investors offering high rates, which did not occur to pay, big losses for investors in Dual structured notes issued in USD followed.

The results showed that the calculus of the VaR for the implicit options could be a base for financial institutions to calculate and provide valuable information about the risk of these investment products, in order to advice them based on the investors risk profile. Especially on the investment products without principal preservation, which are structured with short options positions that in theory can result in big or infinite losses for the investors.

Finally, the proposed research method could be used for regulators in order to assess the banks to probe whether the strikes used in the options to structure the notes offered with attractive rates are likely to occur and whether the those options are sold or bought to their financial partners at market prices.

9. References

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12. *Data of Daily Treasury Yield Curve Rates* located on the site of the U.S. Department of the Treasury, <http://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yield>
13. *Data of the zero coupon bonds denominated in pesos* issued by the Mexican Government (28 days Cetes interest rates expressed in annual percent), found in the site of the Central Bank (Banco de México). <http://www.banxico.org.mx/SieInternet/consultarDirectorioInternetAction.do?accion=consultarCuadro&idCuadro=CF107§or=22&locale=en>
14. *Data of the implicit volatility in options* provided by the Mexican prices provider: VALMER. <http://www.valmer.com.mx/en/>

Appendix A: Figures

Figure 2. Average returns under MXN Structured Notes issued from 2010 to 2012.

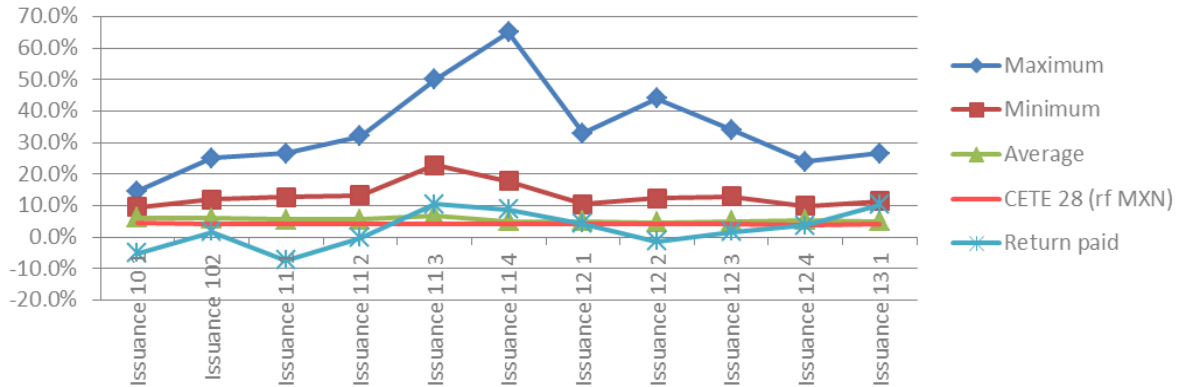


Figure 3. Average returns under USD Structured Notes issued from 2010 to 2012.



Figure 6. Comparison between returns offered in MXN Dual structured notes by the local investment bank and an international Bank.

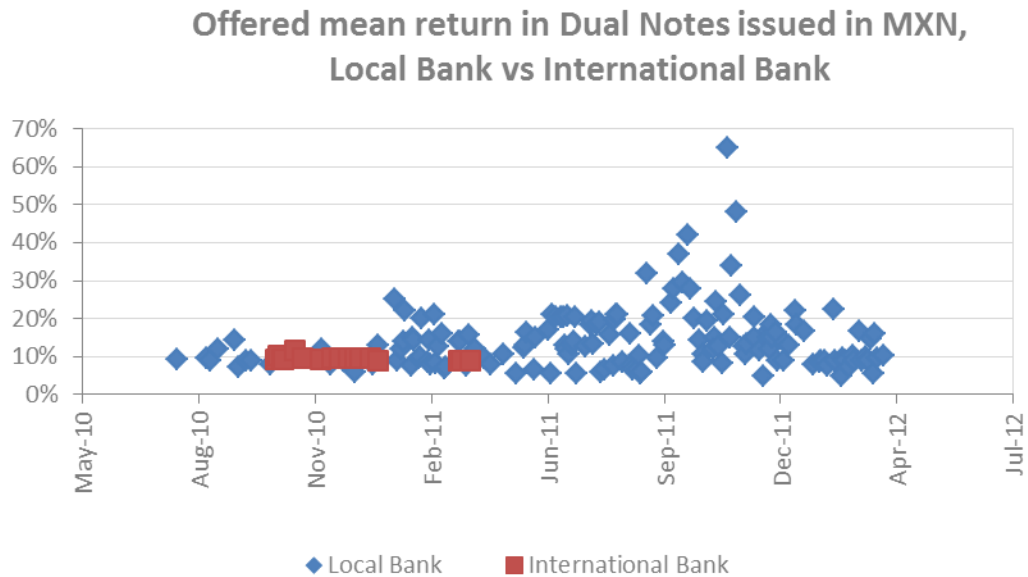


Figure 7. Comparison between returns offered in USD Dual structured notes by the local investment bank and an international Bank.

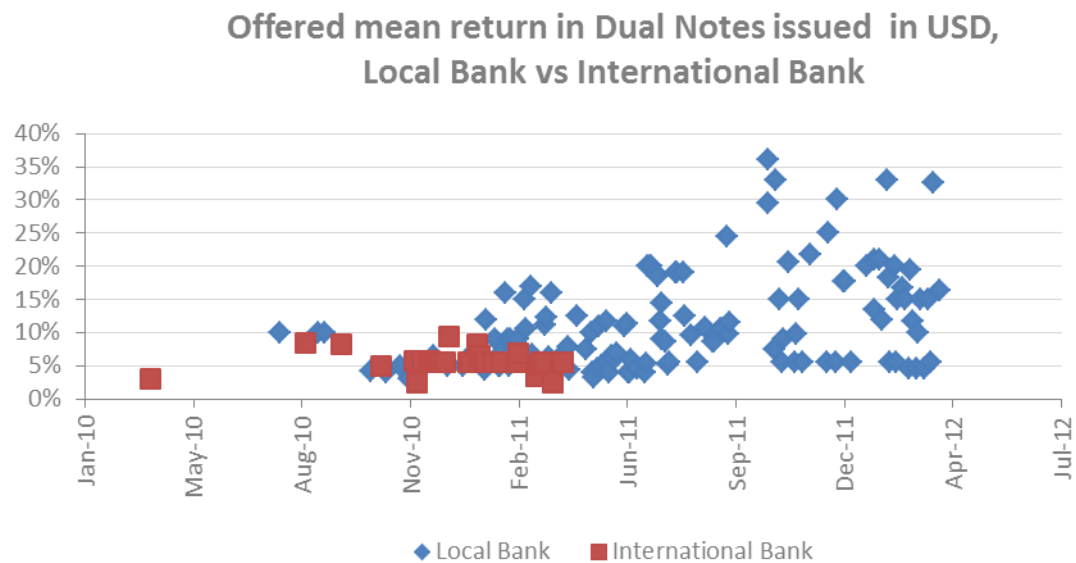


Figure 9. Structured Note issued in MXN (Dual in MXN), using a short put with a foreign exchange rate as underlying asset.

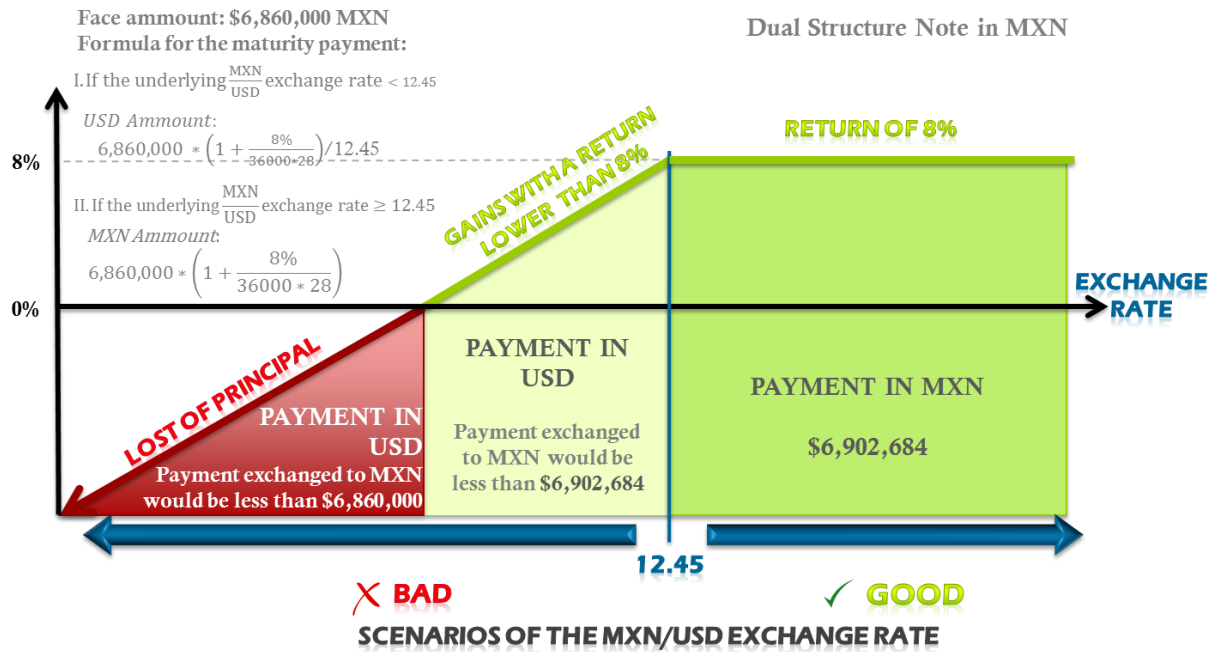


Figure 10. Structured Note issued in USD (Dual in USD), using a short call with a foreign exchange rate as underlying asset.

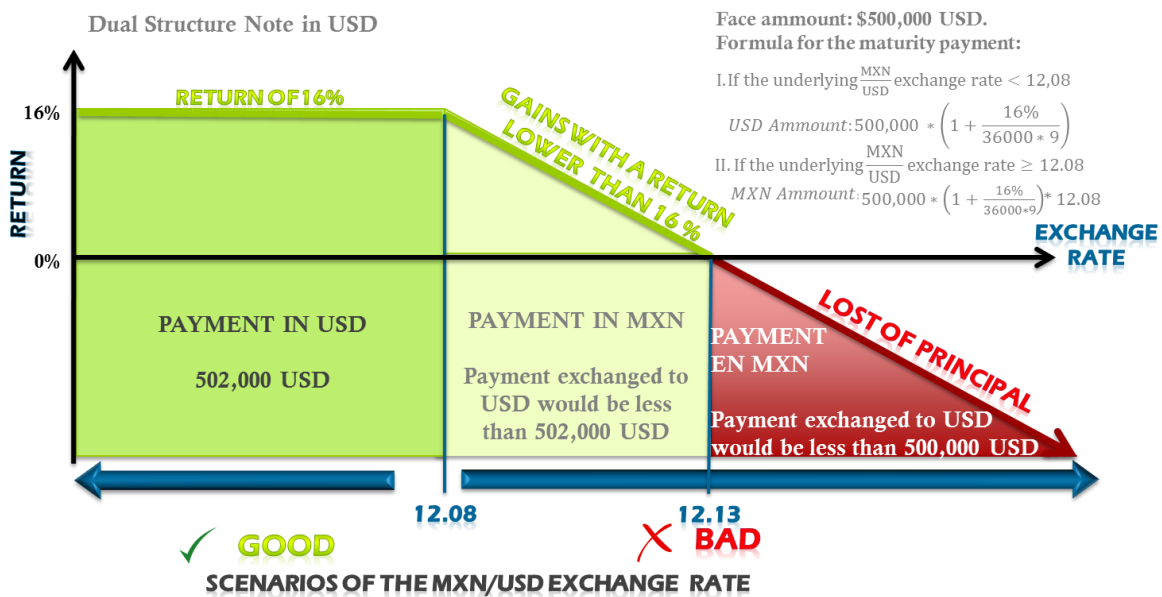


Figure 11. Structured Note with preservation of principal (Cake), using binary options with an index as underlying asset.

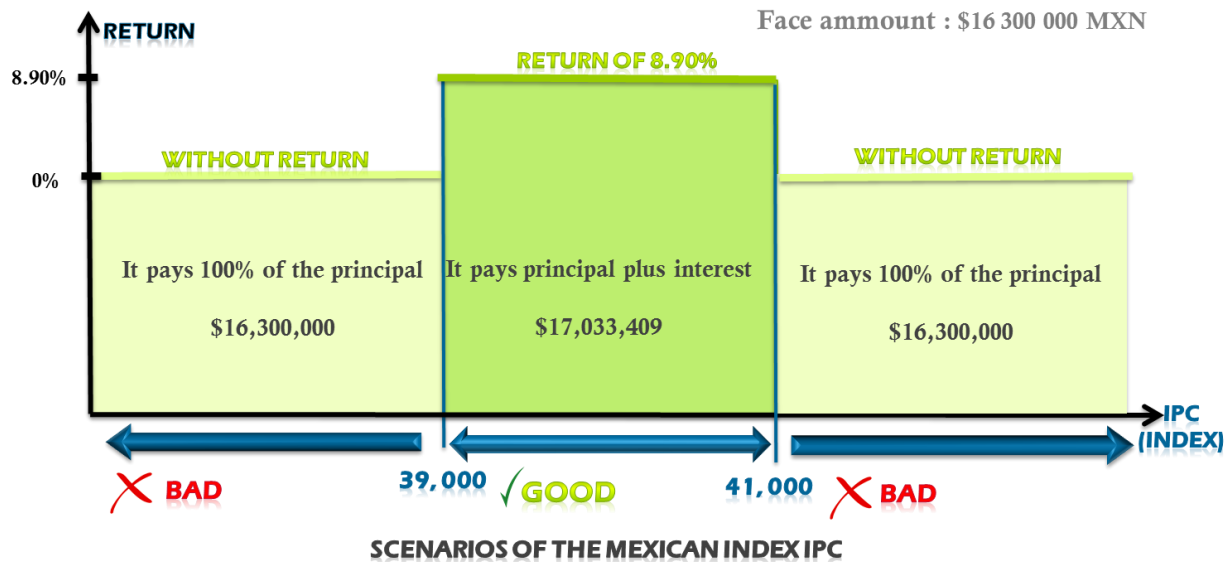


Figure 12. Structured Note with preservation of principal (Range accrual), using a spread option with a foreign exchange rate as underlying asset.

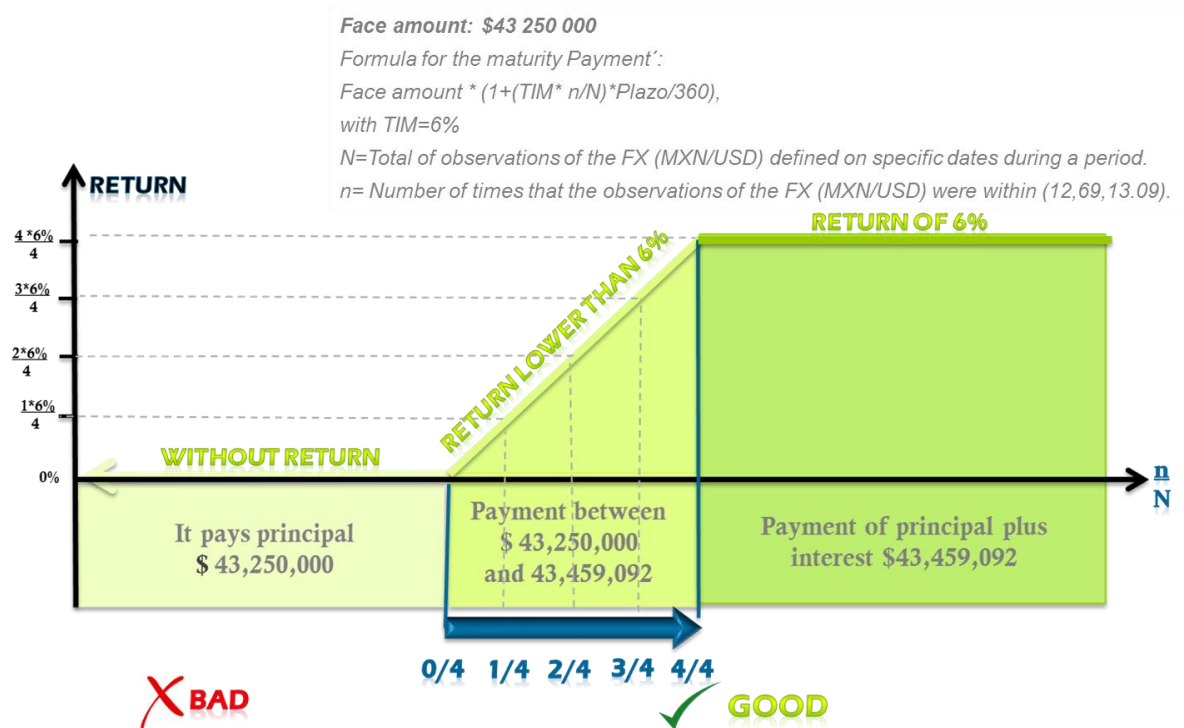


Figure 22. Call Pay-off.

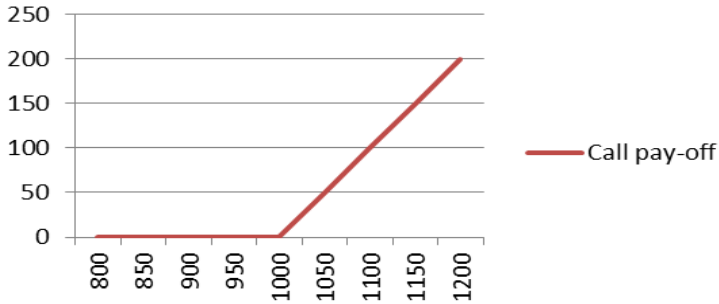


Figure 23. Put Pay-off.

