Tangueros Inc.[1]

"Let the dance begin," muses Brad poetically as he calls his counterparty, Rachel Lesh, at Tangueros Inc. to try out some ideas for a new volatility derivative structure.

Brad Kaiser is the head of the volatility derivatives structuring group at Wright Derivatives. Ms. Lesh is the Assistant Treasurer for risk management at Tangueros Incorporated. Tangueros is a diversified technology and entertainment company. Exhibit 1 provides some basic background information about Tangueros.

Ms. Lesh contacted WD because she is concerned about her future funding liquidity. Roughly a year from now she plans to issue additional new equity to finance a significant expansion of her firm's business. She is bullish about the fundamentals of Tangueros' own business, but she is concerned about getting blindsided in a macroeconomic credit crunch. In particular, a "double whammy" combination of an economic downturn plus high macroeconomic uncertainty could make the market excessively conservative when her stock comes on the market. To be specific, she believes that in a bear market – i.e., given a 10 percent or greater "drawdown" from the peak over the next year to the end-of-year level of the T&F index [2] – each percentage point by which observed index volatility exceeds the normal range of volatility will increase her cost of capital by $20 million. For Ms. Lesh, the "normal range of volatility" extends up to about 5 percentage points above the current at-the-money forward Black-Scholes implied standard deviation (ISD). Above there, she believes investors become overly skittish in recessions. For example, if the hypothetical current Black-Scholes one-year ATM-forward ISD for the T&F index was 12 percent and the realized annualized volatility of T&F returns over the next year was 19 percent, then she estimates her cost of capital would increase by an, in her eyes, unjustifiable $40 million = $20 million * [19 – (12 + 5)].

Before talking to Brad, Ms. Lesh spoke with Rob Dudley at Wrong & Co. who suggested that Tangerueos simply buy some long-dated (e.g., 18 month) out-of-the-money European puts, hold them for a year, and then sell them twelve months from now. His argument is that since puts have a negative delta and a positive vega, they will appreciate in value if returns are negative and volatility increases over the twelve month holding period. Ms. Lesh is unimpressed for several reasons. First, European puts can also appreciate in value if i) stock prices go down but volatility is unchanged or if ii) stock prices stay unchanged but volatility increases. In either case she has to pay up-front for unneeded low price/unchanged volatility and unchanged price/high volatility state-contingent payoffs. This inflates the cost of her hedge since her specific concern is the combination of bad returns and increased volatility. Second, she is not interested in tying her hedging to the future implied volatility in the time window between months twelve and eighteen. Rather, she wants to her payoff to be contingent retroactively on the realized volatility between now and an expiration date in 12 months. Her thought here is that realized volatility has a direct impact on investor psychology in new security issuances.

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[1] The companies, persons, and events in this case are fictional and are intended solely for educational purposes in class discussion. I thank Peter Lee who generously provided many insights about volatility derivative structures and pricing methods. Chris Telmer and Mark Broadie also provided important input at critical stages. Stefano Risa deserves recognition for facilitating the writing of this case. The author is responsible for all opinions and any errors in the case. Last revised: 8-26-2019

[2] The T&F index is a fictitious broad-based stock index.

Modeling stock prices: WD Research has advised Brad to use a stochastic volatility (SV) model to price derivatives on realized path volatility. This means replacing the constant annualized volatility σ in Black-Scholes with a random volatility v_t. The risk neutral dynamics of v_t are usually given by a stochastic differential equation such as $dv_t = \alpha\,[\theta(t) - v_t]\,dt + \phi(v_t)\,dw_t$ where the parameter α and a potentially time-dependent function θ(t) describe the drift of the factor, the term $\phi(v_t)$ is the volatility of the volatility factor (i.e., the "vol vol"), and dw_t is the increment of a continuous-time stochastic process (e.g., a Brownian motion). The volatility dynamics together with the stock price dynamics constitute a SV model.

Aside: Which SV model you choose to use is up to you. Your choice will presumably be driven by qualitative properties you think the volatility process should have and by tractability. Choosing something relatively simple is probably not a bad idea.

Given Brad's choice of a SV model, he needs to calibrate it – that is, he needs to determine the mean-reversion parameter α, the RN attractor function θ(t) – i.e., the levels towards which volatility is pulled – the vol vol ϕ, and the correlation of volatility factor randomness with stock return randomness. To guide his calibration, Brad has market price information for an "implied" calibration (see Exhibit 2). Brad also needs a starting value for the volatility process. Here he intends to use the current ISD from the at-the-money one-month T&F European call (also in Exhibit 2).

Brad's prior phone call: Ms. Lesh has previously told Brad she is not obsessed about hedging realized volatility perfectly. In particular, she is open to creative ideas about how to structure her exposure to future index randomness opportunistically to take advantage of any "anomalies" in the current market pricing of volatility. For example, she would be comfortable with structures specified in terms of "down" and "up" volatility, corridor volatility, or similar notions rather than total index volatility if that will save her money on a risk-adjusted basis. As a first step, Brad compares the Black-Sholes ISDs for the current T&F index option prices with historical T&F ISDs in Exhibit 3 to see if anything leaps out.[3] "Hmmm," thinks Brad, "the current ISD smile looks quite different from how it normally looked in the past. I wonder if it makes sense to do some structuring around that too."

Other considerations: Here are some additional issues to consider in this deal.

- Conceptually, what considerations should determine the specification of the volatility process?
- What risk exposures does Wright Derivatives have in this deal? How should WD hedge them?
- There are a variety of ways prices can be quoted. Please include prices per $1 notional as well as total costs for the full deal.

[3] In this context, the Black-Scholes ISDs are being used as a quick-and-dirty option pricing diagnostic.

Words to the wise about modeling and other issues when doing the case:

- More realistic numerical implementations are preferred to less realistic implementations, but don't go overboard numerically! Your priority should be on completing a valuation that is <u>logically</u> sound and on understanding and being able to explain the implications of any numerical or modeling shortcuts.
- The contractual and simulation time granularity is up to you. For example, computing realized volatilities based on monthly time steps is fine for many possible structures.
- If you have trouble calibrating exactly to the numbers in the case, just try to get in the ballpark. After all, this is financial *engineering*, not financial physics and market prices have "microstructure noise" in them that is related more to the current supply and demand for liquidity than to future price dynamics.
- Once you've completed a basic analysis, then you will be able to think more clearly about value-added refinements if you have time left over.
- If you need additional background information for your sales pitch, feel free to make up things as long as they are plausible and consistent with the spirit of the case.
- The convention for volatility products is to work with annualized volatilities. Don't forget to annualize the SDs of your periodic returns and also scale them appropriately (e.g., should the numbers be in decimal or percentages?).

Presentation Format:

- In your presentation you can assume your client is knowledgeable about derivatives, but that she is primarily interested in how your proposal will help solve her business problem.
- Following the sales pitch (10 minutes), client Q&A (10 minutes), and the technical and risk management briefing of your boss (absolutely no more than 15 minutes), there will be 40 minutes or so for general Q&A about the details of the modeling and technical implementation and about profitability and risk management issues at Wright Derivatives.
- You may be asked questions about alternative parameter values. Bring your spreadsheet (or whatever numerical package you use) to the presentation so, if needed, you can plug them in your model and discuss them.

Written documents: Before the start of your presentation, you should submit the following written items via the digital drop box in BB.

- Copies of your sales pitch and boss briefing PowerPoint slides.
- A short summary "term sheet" with all key contractual terms for your deal (e.g., payoff rules, strike prices, timing issues, etc.)
- An 8-10 page deal memo to your boss describing the deal structure, your pricing and calibration methodology and results, your quantitative risk assessments, and your risk management strategy, and anything else you think your boss might be interested in even if, given the time constraint, you don't plan on including it in your verbal boss briefing.
- A short calibration questionnaire for grading purposes. In particular, since different teams may work with different dynamics and different deal structures, it is helpful to have a standard benchmark to assess the numerical properties of your calibration and simulation. The questionnaire should answer the following questions:

- ❑ What are the equations of your SV process? What are your calibrated parameter values?
- ❑ What are the cross-path mean and standard deviation of your simulated volatilities in month 12?
- ❑ What are the cross-path mean and standard deviation of your annualized realized path volatilities?
- ❑ What are the cross-path mean and SD of your simulated stock prices in month 12?

Evaluation criteria: Teams will be evaluated on financial intuition, marketing quality, structuring creativity, and technical proficiency. Some specific considerations are:

- *Pricing and structure.* Completing the analysis -- structuring and pricing your proposal – is clearly a necessary first step. You should also be able to explain the pros and cons of your modeling choices.
- *Intuition.* You should be able to explain how model assumptions and contractual characteristics determine the deal value and deal risk.
- *Salesmanship.* The sales pitch should focus on the "forest" (the business drivers behind your proposal) rather than the "trees" (modeling details).
- *Clarity.* When working with sophisticated financial products, clarity and intuition are vital.

Good luck!

Exhibit 1
Background Information about Tangueros

Most recent annual EBIT	$140 million
Market value of equity	$835 million
Debt outstanding	$550 million

Lines of business: Dance instruction equipment, entertainment, roses, video technology

Exhibit 2
Current Prices for European T&F Index Calls and Other Market Data

Annualized 1 year treasury rate: 4.11 percent

Black Scholes ISD for the at-the-money one-month T&F European call: 11 percent

Prices for longer-dated T&F European Calls:

Initial index value normalized to $100

Expiry (yrs)	0.25		
Strike	95	100	105
Price	$6.5757	$2.8223	$0.6335

Expiry (yrs)	0.50		
Strike	95	100	105
Price	$8.1165	$4.3850	$1.7263

Expiry (yrs)	0.75		
Strike	100	105	110
Price	$6.0865	$3.1820	$1.2347

Expiry (yrs)	1.00		
Strike	100	105	110
Price	$7.7710	$4.7369	$2.4165

Note: Different strikes for 3 and 6 month calls versus 9 and 12 month calls so that middle call is close to at-the-money forward.

Exhibit 3
Historical T&F Index Black-Scholes ISD Smiles over past 3 years

Differences in At-The-Money-Forward Call ISDs:

ISD(ATMF+5, Maturity) - ISD(ATMF-5, Maturity)

	3 month	1 year
95 percent upper	-0.033	-0.025
Mean	-0.044	-0.037
5 percent lower	-0.050	-0.041

Note: 0.01 = 1 percent