Goldman, Sachs & Co. Nikkei Put Warrants—1989

Teaching Note

Objective

This case allows students to understand how a financial institution can exploit global capital markets to create a profitable new product. Specifically, the case is intended to illustrate (a) how regulations inhibit, give rise to, and influence the structure of a new financial product, (b) how product design, marketing and production interact with one another and affect the costs of new financial products, and (c) how firms, acting as temporary monopolists with reputational concerns, set prices.

Synopsis

The investment bankers at Goldman Sachs & Co. (GS&Co.) have access to a new raw material—favorably priced puts on the Nikkei Stock Index—from which they can fashion an investment vehicle that retail U.S. investors will demand. The case forces students to review the business decisions that GS&Co. must make to bring this product to market. These design, marketing, production, and pricing decisions are guided by the firm's understanding of consumer preferences, likely rivalry, reputational impacts, regulatory concerns, and financial engineering requirements.

Suggested Assignment Questions

1. Why were Nikkei-linked Eurobonds issued? Make sure you understand how the embedded puts can be stripped from the Nikkei-linked Eurobonds, and how these puts can be repackaged and resold. What other type of instrument could you design to satisfy the preferences of the alleged buyers of these bonds? As a bank owning these puts, what can you do with them?

2. Study the proposed design for the Nikkei Put Warrants (NPWs). What features are primarily designed to appeal to the target U.S. retail clientele? What features are primarily designed to simplify the process of creating (hedging) the NPWs? How do the features of the proposed NPWs differ from those sold to institutional investors? To retail investors in Toronto?

3. Why is the Kingdom of Denmark issuing these warrants? What do they gain? What risks do they bear in the proposed transaction?

This note was prepared by Professor Peter Tufano for the sole purpose of aiding classroom instructors in the use of Goldman, Sachs & Company Nikkei Put Warrants—1989, HBS No. 292-113. It provides analysis and questions that are intended to present alternative approaches to deepening students' comprehension of business issues and energizing classroom discussion.

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4. What risks does GS&Co. bear in executing this transaction? How are these risks mitigated? Specifically, compare how the security design chosen and the raw materials available affect the exchange rate risk faced by GS&Co. and by BT Bank of Canada (sellers of the first Toronto-listed Nikkei put warrant). Describe how you think GS&Co.'s QUANTOS product will mitigate the risk of exchange rate changes over time.

5. Assuming GS&Co. must invest $1.00 per warrant to hedge its currency risk using QUANTOS, what is the lowest price per warrant that GS&Co. could charge for the currency-hedged NPWs and still break even?

   a. If the NPWs were European-style, and not American-style, what would the minimum break-even be?

   b. How will the American-style feature affect GS&Co.'s break-even? Why? How much of a difference do you think it will have on the break-even price you calculated?

6. How should GS&Co. price the warrants? Why?

Case Issues and Teaching Plan

The case discussion can be divided into five major sections: (a) the fundamental forces of supply and demand for Nikkei Put Warrants; (b) the interaction of design, marketing, and production decision; (c) producing a fixed currency put warrant—the problem of currency hedging; (d) pricing the Nikkei Put Warrant—cost, competitive, informational, and reputational concerned; (e) postscript.

A. The Supply and Demand for Nikkei Put Warrants (30 Minutes)

While as early as 1987 GS&Co. was aware of strong consumer demand for Nikkei Put Warrants for speculation and hedging, the firm did not seriously consider the product until more than a year later. The instructor can probe why the market did not immediately satisfy this demand. The case suggests two explanations: regulation and production costs. The instructor should ask students to speculate how Japanese regulators can prevent U.S. firms from selling securities to U.S. citizens. Students should immediately recognize that GS&Co. is a global firm that does business in Japan. The firm is therefore under the direct and indirect regulatory control of the Japanese authorities. In addition, GS&Co. would have to obtain permission from the Japanese firm owning the rights to the Nikkei 225 name, which was clearly under the control of the Japanese regulators. Finally, the case mentions an informal surveillance agreement between U.S. and Japanese exchanges regarding products of mutual interest. AMEX would not proceed without the permission of the Tokyo Stock Exchange, which was regulated by Japanese authorities.

The second factor preventing the earlier sale of NPWs was the lack of a "readily available and liquid source of puts." Theory suggests that GS&Co. could have dynamically replicated puts by adjusting its positions in stocks (or futures) and in risk-free assets. However, dynamic replication may have been unattractive if transactions costs were high or if GS&Co. could not successfully short securities to produce the required payoff. The development that stimulated the Nikkei put market was the emergence of a class of investors willing to sell puts on the Nikkei. Due to regulatory guidelines, Japanese life insurers could only pay dividends out of interest income; thus they had strong competitive incentives to boost their income. Yet, holding total return constant, an investor can increase yield by taking on greater risk of principal loss, such as by holding junk bonds, in which the promised income is high because return of principal is uncertain. By selling Nikkei redemption-linked bonds, the issuer effectively sells the investor a bond plus a capped put. The put premium compensates issuers for increasing the current yield on the bond.

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Exhibit 2 gives examples of two Nikkei-linked offerings. The instructor should work through the summary of the terms so that students can see the nature of the investors' exposure to the Nikkei. The investor can be thought of as owning a coupon-paying bond, owning puts with a low exercise price, and writing puts with a high exercise price. For example, the owner of each Skopbank bond with a face value of ¥100 million is long a note paying ¥107,000,000 at maturity, short 12,551 one-year puts on the Nikkei with an exercise price of ¥31,870.04 and long 12,551 one-year puts on the Nikkei with an exercise price of ¥23,902.53. Alternatively, one could express the note as a ¥7 million coupon payment, a long position in 12,551 calls on the Nikkei with an exercise price of ¥23,902.53, and a short position in 12,551 calls on the Nikkei with an exercise price of ¥31,870.04. **Exhibit TN-1** presents one analysis of the Skopbank offering, based on the information given in the case. The deal has a value far less than its selling price, suggesting that this offering is overpriced, which allows the issuer or its counter-parties to benefit. This type of pricing provides GS&Co. with relatively "cheap" puts on the Nikkei, the basis for their new product. In addition, the below-market level of pricing is consistent with the explanation that the investors were willing to pay a premium to relax regulatory constraints. The *IBM-Japan* case study[1] provides another example of an instance in which regulation affected Japanese investors' demands and gave rise to opportunities for attractive funding by non-Japanese corporations.

As the case explains, issuers of Nikkei-linked bonds typically had no interest in owing ¥-denominated, fixed-rate instruments with indexed principal payments. Issuers like Skopbank could enter into interest rate and currency swaps to transform the instrument into LIBOR-linked, US$-denominated obligations. Furthermore, by entering into side agreements with financial institutions like Bankers Trust or Goldman Sachs, the issuer could sell the capped put in return for which it was paid the put premium. In essence, a firm like Skopbank issues a fixed-rate bond, but divides its principal payments between the holder of the note and the holder of the put.

Once it owns the capped puts, what can GS&Co. do with them? It can hold them, sell them to institutions, or sell them to households. By holding the puts, GS&Co. may be using them as inventory in anticipation of a later sale, speculating on the value of the Nikkei, or hedging its Nikkei exposure. GS&Co. has not only direct portfolio exposure to the Nikkei 225, but also indirect economic exposure to the Japanese stock market and economy. By holding puts, it hedges against a drop in profitability in Japan and elsewhere due to a serious fall in the Japanese stock market.

If a bank chooses to sell its newly-acquired capped puts on the Nikkei, it must evaluate the relative profitability of sales to various parties. Sales to institutions are likely to bring lower revenues (institutions would tend to be more sophisticated and have more alternatives to the puts), but are also likely to have significantly lower costs (marketing, distribution, registration, etc.) Sales to a retail clientele may produce greater profits, but the implications of designing, producing, and marketing a product to retail clientele are non-trivial, as the next portion of the discussion will uncover.

B. The Interaction of Design, Marketing, and Production (20 Minutes)

This part of the discussion allows students to realize that every element of the proposed terms for the NPWs is the product of a conscious decision driven by consumer preferences, production technology, and regulation. Furthermore, marketing decisions, such as the decision to satisfy investors by fixing the exchange rate in advance, may have profound production implications. **Exhibit TN-2** summarizes the key decisions, alternatives to these decisions, forces that led to the chosen decision, and implications of this decision for GS&Co. The instructor should lead students through a "reverse-engineering" of GS&Co.'s product, much as its rivals did when the deal came to market in early 1989.

For example, the decision to market a liquid, retail-oriented product, listed on the NYSE (vs. the CBOE) meant that GS&Co. had to find an issuer for the warrants. While GS&Co. could have issued the

[1] HBS Case No. 286-074.

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warrants itself, SEC rules would demand GS&Co. reveal a great deal of information, which as a private partnership it had chosen not to disclose. (The instructor may want to spend a few minutes on what types of disclosures GS&Co. might be most reluctant to make and why.) Therefore, GS&Co. needs to find an issuer. Unless they could find a firm willing to expose themselves as a put-writer, the issuer will demand that GS&Co. sell them an offsetting contract so that their Nikkei exposure is neutralized.

The case explains that the Kingdom of Denmark has agreed to serve as the issuer. GS&Co. would sell the Kingdom an exactly-offsetting put to the one that the Kingdom would offer, and would pay the Kingdom $1.3 million to engage in the pair of offsetting transactions. The $1.3 million represents (a) payment for bearing the credit risk of GS&Co., (b) payment for renting the Kingdom's balance sheet, name, and credit rating, and (c) a sharing of the profits by innovation. To the extent there are profits to be made by selling NPWs, and to the extent that the supply of issuers is limited, the Kingdom can effectively demand and receive some portion of these profits.

C. The Exchange Rate Implications of Selling Fixed-Exchange Rate Nikkei Put Warrants (20 Minutes)

One design decision that makes the proposed NPW substantially harder to produce is its treatment of exchange rates. Consider three different puts, whose payoffs can be expressed as follows:

a. Maximum $(N_0 - N_1, 0)/¥_1$

b. Maximum $(N_0 - N_1, 0)/¥_0$

c. Maximum $(N_0/¥_0 - N_1/¥_1, 0)$

where N_0 and $¥_0$ are the spot levels of the Nikkei and the ¥/$ exchange rate at the time the contract is first written, while N_1 and $¥_1$ are the spot levels of the Nikkei and the ¥/$ exchange rate at the time the put is exercised.

The puts that GS&Co. owns are type (a), where the payoff is determined by the Yen value of the Nikkei translated into US$ at a floating exchange rate. The puts that GS&Co. owes to the Kingdom of Denmark (and to investors in the NPWs) are type (b), where the Yen value of the Nikkei is translated into dollars at a previously set, fixed-exchange rate. Marketers told GS&Co. that retail investors would prefer fixed exchange rate puts, hence, this structure was chosen. Note that BT Bank of Canada reached a different conclusion: The put warrants sold in Toronto described in **Exhibit 3** use a floating exchange rate (type (a) for NKP.WT) and the combination fixed and floating rate (type (c) for NKP.WT.A). Had GS&Co. designed its NPW similar to the Canadian NKP.WT, it would have had no foreign exchange exposure, as the buyer of the put would bear the risks of changes in the exchange rate.

If GS&Co. were to leave its exchange rate exposure on the pair of transactions unhedged, its profits from the NPW deal would be a function of future exchange rates. To see this, consider GS&Co.'s profits at expiration of the puts:

	Proceeds from Put owned	- Payments to Kingdom
=	$\text{Max}(N_0 - N_1, 0)/¥_1$	$- \text{Max}(N_0 - N_1, 0)/¥_0$
=	$\text{Max}(N_0 - N_1, 0) \times (1/¥_1 - 1/¥_0)$	

Thus, if its currency exposure is left unhedged, GS&Co. will lose when the Nikkei falls ($N_0 - N_1 > 0$) and the dollar appreciates relative to the yen ($1/¥_1 - 1/¥_0 < 0$). Yet this is precisely the historical relationship between the level of the Japanese stock market and the exchange rate.

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Students may find it easier to think about GS&Co.'s exposure if they calculate its payoffs under a few simple scenarios. See **Exhibit TN-3**. What these examples show is that unless it manages the currency component of its exposures, GS& Co. will run the risk of losses. Furthermore, given the historical pattern of relationships between exchange rates and the Japanese stock market, GS&Co. is likely to face either no currency exposure (if the Nikkei rises and the dollar depreciates) or large losses (if the Nikkei falls and the dollar appreciates). Because the level of its currency exposure is contingent on the level of the Nikkei, GS&Co. cannot merely purchase a currency forward contract or a currency option at the initiation of the contract and leave that contract in place over the life of the NPWs. However, just as a firm can create a non-linear exposure using a dynamic replication strategy, GS&Co. can create the proper currency exposure. At the simplest level, as the Nikkei falls and the dollar appreciates, Goldman wants to hold more dollars to be able to meet its obligations under the put contract. Its dynamic hedging strategy is, thus, a function of volatility of both the Nikkei and the exchange rate, as well as the correlation between these two.

D. Setting the Price of the Nikkei Put Warrant: Cost as a Boundary of Price

Ultimately, GS&Co. must determine how to price its first NPW offering. This student discussion can be divided into four sections: (1) What are the costs of producing and selling the NPW? (2) Which of these costs are relevant in pricing the deal? (3) How would GS&Co. price the deal in a competitive market? (4) How do the prices of substitute goods as well as reputation concerns affect its pricing decision?

1. *Costs of producing and selling the NPW*. Producing the NPW involves buying an American-style put from Trading and Arbitrage's inventory and then laying on an appropriate currency hedge so as to produce a position whose payoffs exactly replicate those of the NPW which GS&Co. will sell. There are numerous recent technical academic papers which attempt to price this type of fixed-exchange rate index option.[2] If the instructor wishes to use the case as an advanced pricing exercise, he or she may consult these papers.

   Chen et al. (1992) do not discuss the complexities of the currency hedging dimension of the NPWs. Gruca and Ritchken (1991), Clyman (1992), and Reiner (1992) develop closed-form solutions for the value of European-style fixed exchange rate index warrants. Gruca and Ritchken also discuss the pricing of American-style fixed exchange warrants, but do not report the pricing results. Shaw et al. (1992) have a complete discussion of the specific NPWs issued and report valuations of the American style warrants. They show that fixed exchange rate warrants may be worth more or less than floating exchange rate warrants, depending on the volatility of the exchange rate and its correlation with the Nikkei.

   A negative correlation between the Nikkei and the Y/$ exchange rate increases the value of the fixed exchange rate warrants, because with drops in the Nikkei and appreciation of the dollar, the dollar payoff to fixed exchange-rate holders will be greater than to floating exchange rate warrant holders, as demonstrated in **Exhibit TN-3**. With negative covariance, increases in the variance of the exchange rate tend to increase the value of the floating-rate warrant over the fixed-rate warrant. The positive price of the QUANTOS contract is predicated on a negative correlation between the Nikkei

2. See Julian Shaw, Edward O. Thorp, and William T. Ziemba, "Convergence to Efficiency of the Nikkei Put Warrant Market of 1989-1990," (unpublished manuscript, 1992); E. Gruca and P. Ritchken, "Exchange-Traded Foreign Warrants," (unpublished manuscript, Case Western Reserve University, 1991); Dana Clyman, "Arbitrage and Fixed Exchange Rate Nikkei Put Warrants," (unpublished doctoral dissertation, Harvard Business School, 1992); K.C. Chen, R.S. Sears and M. Chahrokhi, "Pricing Nikkei Put Warrants: Some Empirical Evidence," *The Journal of Financial Research* XV (1992), 231-251; and Eric Reiner, "Quanto Mechanics" in *From Black Scholes to Black Holes: New Frontiers in Options* (London: Risk Magazine Ltd., 1992).

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and the exchange rate and positive volatility of the exchange rate. Were there to be a non-negative correlation of the Nikkei and the exchange rate, the QUANTOS feature could have had a negative price, i.e., in theory J. Aron would pay GS&Co. to fix the exchange rate in advance. Shaw et al. argue that with a near zero correlation, the fixed exchange-rate warrants should have been worth less than floating-rate warrants, and that, therefore, consumers may have over-valued the fixed exchange rate feature.

While students should be able to grasp the conceptual points regarding the impact of correlation on the NPWs' pricing, they are unlikely to grasp the nuances of the pricing models. The case presents a simplified way to think about the problem, separating the currency hedging production costs from the put warrant.

The developers of the NPW in GS&Co.'s Capital Markets group can purchase a contract from another division of GS&Co. which would hedge out all of the currency risk of the NPW. If we take the quoted transfer price of this "QUANTOS" option as the competitive price to provide the necessary hedging for the product, i.e., as the amount of money GS&Co. would have to invest at the outset to establish a dynamically replicated currency option linked to the value of the Nikkei, then the cost to produce the NPW can be determined.

First, the three-year yen-denominated at-the-money American put that Capital Markets will buy from Trading and Arbitrage is priced at an implied volatility of 13.6%. **Exhibit TN-4** shows the cost to create this yen-denominated put is approximately $2.60. Students who price this as a European put will arrive at a much lower price of approximately $1.76. Instructors may want to use this large difference to revisit the issue of early optimal exercise of American puts. Next, each put will cost GS&Co. $1.00 to buy the necessary currency hedging. Thus, the financial engineering cost of the NPW is about $3.60 per warrant.

In addition to its financial engineering costs, GS&Co. incurs other costs for legal and listing fees, selling commissions, a fee to the Kingdom of Denmark, and ten person years of development at GS&Co. The discussion can then turn to how these different costs should enter into GS&Co.'s pricing decision.

2. *Identification of relevant costs*. Students should be pressed to ascertain which costs are sunk, which are fixed, and which are marginal. As of December 1989, the product development costs (ten person years) are sunk costs, as are much of the $350,000 in legal and listing fees. While the precise terms of the agreement between GS&Co. and the Kingdom of Denmark are not public, one might assume that the Kingdom of Denmark's fee is conditional on the deal going forward. Thus, it is not likely a sunk cost at this time. Whether it is a fixed or variable cost is not clear. The contract might require GS&Co. to pay $1.3 million for the right to issue up to 9.5 million warrants, or might effectively charge GS&Co. a certain fee per warrant, so that if a smaller deal is done, the payment to the Kingdom of Denmark would be under $1.3 million. The analysis in the remainder of the teaching note assumes that the $1.3 million is a fixed cost to GS&Co., at least for issuing no more than 9.5 million warrants. Finally, the financial engineering costs and the distribution costs are likely to be pure variable costs. Once students have identified the nature of the different costs, they then have to determine how to use this information to set a price for the product.

3. *Pricing the deal: pure competition, monopoly, and imperfect competition*. In a perfectly competitive environment, GS&Co. would be a price-taker, and price would be set at marginal cost, which in this case might be approximately $3.91 (See **Exhibit TN-5** for cost summary.) While the sale of NPWs to retail consumers will eventually resemble a competitive market, it is not clear that it is a competitive market in December 1989. There are not large numbers of rivals offering exactly comparable products to U.S. retail investors. In fact, as the case states, as of December 1989, there are no comparable products sold to U.S. retail investors.

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Is GS&Co. a monopolist? Perhaps for a very short period of time, GS&Co. will enjoy no direct competition.[3] However, it is likely that it will face almost immediate competition after its deal comes to market. Students must immediately recognize that GS&Co. faces rivals who have equal access to the raw material (Nikkei puts), similar experience with investors (sellers of currency warrants), and sufficient distribution capability to produce NPWs very quickly once GS&Co. breaks through the regulatory barriers. Through limit-pricing GS&Co. is unlikely to keep potential rivals at bay.

In the short-run, why not set a profit-maximizing price and quantity, i.e., act as a monopolist? Here, GS&Co. would set the price and quantity so that marginal revenue exactly equals marginal cost. If the sum of the marginal profits is less than its fixed (but not yet sunk) costs of $1.3 million, GS might choose to cancel the issue. While GS&Co. may know its marginal costs well, it has very little information about marginal revenues, i.e., the shape of the demand curve for Nikkei Put Warrants. While Canadian floating exchange rate NPWs are selling with an implied volatility of almost 33%,[4] this product merely provides one data point on the intersection of supply and demand in another country for a fundamentally different product.

Finally, GS&Co.'s pricing decision is made even more complicated by the impact of pricing on the firm's reputation, an intangible but highly valuable asset. A higher price on the NPW deal might maximize short-term profits but damage relationships with investors, the Kingdom of Denmark, and the selling group. A lower price on the first NPW deal would lower GS&Co.'s profits, but make investors, its selling group, and the Kingdom of Denmark pleased.

Exhibit TN-7 summarizes various pricing boundaries: GS&Co.'s marginal cost, its average cost (for 9.5 million units), estimates of its "fully-loaded" costs (including estimates of sunk costs), and an estimate of the price implied by the sales of NKP.WT in Canada.

E. Postscript

GS&Co. went ahead with the deal as described. It offered 6.5 million warrants on January 12, 1990, at a price of $4.05, and five days later issued an additional 3.85 million identical warrants at a price of $5.375 per warrant. The instructor should ask students why GS&Co. chose a two-tranche selling strategy. The low price on the first deal gives GS&Co. a small profit, ensures the success of the offering, and allows them to collect information on demand. With that information in hand, a second tranche could be issued at a higher price.

As expected, Goldman's "monopoly" was short lived. **Exhibit TN-8** shows that Salomon Inc. entered with an offering under its own name on January 17. A few weeks later, Bankers Trust issued a floating exchange rate NPW. In April 1990, Paine Webber issued a NPW. (Goldman's strategy of selecting a co-manager who would not compete with them was unsuccessful.)

Concerns over the reputational impact of the initial pricing of the NPWs proved to be relevant for one of GS&Co.'s rivals, Merrill Lynch & Co.'s NPW immediately fell in value after it was issued, leading the *Washington Post* (Feb. 6, 1990, p. D1) to run a story entitled, "Merrill's 'Nikkei' Security Backfires":

The nation's biggest brokerage firm . . . has blundered by selling a complicated new security to investors at too high a price, according to several Wall Street sources . . . Unlike the offerings managed by Salomon Brothers, Inc. and Goldman Sachs & Co., which went up in price after they were issued, the Merrill product immediately

3. The period of "monopoly" enjoyed by innovators of new financial products is exceedingly brief. See P. Tufano, "Financial Innovation and First Mover Advantages," *Journal of Financial Economics* (1989).
4. See **Exhibit TN-6** for an analysis of the implied volatility of the Canadian NKP.WT.

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traded below the initial offering price, prompting some angry investors to consider refusing to pay Merrill for the shares.

The rush of U.S. firms to issue NPWs, in conjunction with declines in the Tokyo stock market, led Japanese authorities to stifle further NPW issues by asking the AMEX and the investment banks to voluntarily refrain from making any further issues.[5] NPWs that were reportedly planned for issue did not come to market after this request by the Japanese.

Exhibit TN-9 tracks the Nikkei 225 index and the exchange rate over the life of the GS&Co. NPW. Due to the fall in the Nikkei, substantial numbers of the warrants were exercised early. Clyman (1992) reports that 52% of GS&Co.'s warrants were exercised in 1990, and another 31% of the total were exercised in 1991. **Exhibit TN-10** shows that investors who bought the GS&Co.'s warrants at issue and held them to maturity enjoyed annualized returns of 91% and 74%, respectively for buyers of the first and second tranches. Had GS&Co. done no currency hedging, at exercise it would have made $4.50 per warrant, as the exchange rate *fell* to 125.35¥/$ at maturity while the Nikkei also *fell* (failing to act in accordance with the historical negative correlation between these two series). GS&Co.'s payments to the Kingdom of Denmark would have been $28.24 per warrant, while its payments from holding floating-rate warrants would have been $32.75. GS&Co. has not revealed the details of its currency hedging or its profits on this transaction.

5. Craig S. Smith and Kevin L. Dunn, "Tokyo Exchange Pushes to Halt U.S. Sales of Nikkei Warrants," *The Wall Street Journal*, (April 26, 1990) p. Cl.

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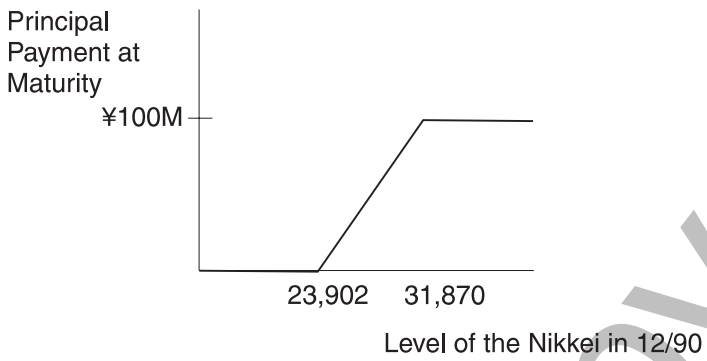
Exhibit TN-1

Analysis of the Skopbank Nikkei-linked note offering (described in Exhibit 1 in the case)

Analysis of the Skopbank Offering

At maturity, the holder of ¥100 million Skopbank note will receive a 7% coupon plus a principal payment which depends directly on the level of the Nikkei:



Thus, one can express a ¥100M Skopbank note as either:

(a) Long ¥7M coupon paid in one year
+ Long 12,551 Calls on Nikkei (European, K = 23,902, T = 1 year)
- Short 12,551 Calls on Nikkei (European, K = 31,870, T = 1 year)

(b) Long ¥7M coupon paid in one year
+ Long a bond paying ¥100M principal in one year
+ Long 12,551 Puts on Nikkei (European, K = 23,902, T = 1 year)

- Short 12,551 Puts on Nikkei (European, K = 31,870, T = 1 year)

Valuation of the Skopbank Offering

If the coupon is discounted back at 6.5%, as suggested in **Exhibit 1**, it has a present value of about ¥6.6M. Using interpretation (a) above, we can value the difference between these two European calls on the Nikkei given different estimates of the volatility of the Nikkei. Based on the current historical and implied volatilities of the Nikkei, the value of the Skopbank note is far less than its offering price. For example, if we take GS&Co.'s estimate of volatility (13.6%), the note is worth approximately 6.6 + 92.9 = 99.5 M at time of issue, far less than the 101.125 selling price. According to the case, this difference may be due to the eagerness of Japanese financial institutions to purchase higher levels of coupon income.

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Exhibit TN-1

Analysis of the Skopbank Nikkei-linked note offering (described in Exhibit 1 in the case) (Continued)

		Value of the Option Component			
Assumed Volatility	Value of Call K = ¥31870	Value of Call K= ¥23902	Value of Call Pair: Long K = 23,902; Short K = 31,870	Value of 12,551 Options Pairs (in ¥ million)	Valuation of ¥100 M face value Skopbank Note that sold for ¥101.125 M (in ¥ M)
6%	¥8111	¥15587	¥7476	93.8M	100.4
9%	8115	15587	7472	93.8M	100.4
13.6%	8183	15587	7404	92.9M	99.5

Assumptions: Nikkei level at issue is 38,200; dividend yield on Nikkei is .49% per annum, risk-free rate is 6.375% (**Exhibit 4**), term is one year, exercise price and volatility as given above. For final column, coupon valued at ¥6.6 million.

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Exhibit TN-2

Implications of design decisions for Nikkei Put Warrants

Decisions: Put characteristics	Possible Alternatives	Why chosen	Implications
Three-Year Life	Any expiration date possible	1. Amex wanted long life, so as to avoid regulatory turf war with options exchanges. 2. Raw material (puts in inventory) have lives under four years 3. Investors wanted longer lives.	1. Solution responds to production requirements.
Uncapped Put	Capped Put	1. Consumer preferences	1. Different hedging by Trading and Arbitrage, if uncapped product is not in inventory.
American-style	European-style	1. Consumer preferences	1. Different hedging by Trading and Arbitrage, because of possibility of early exercise.
Label instrument a "warrant"	Label it an "option"	1. Different regulation and exchange. 2. Some holders of warrants cannot hold options.	1. Solution responds to marketing and regulatory constraints.
List on American Stock Exchange	List on other exchange or sell without listing (e.g. limited partnership interest)	1. Investors demand for liquidity	1. Need to pay and find issuer, because GS&Co. reluctant to reveal information to SEC. Issuer unlikely to be U.S. corporation, due to accounting treatment. 2. Issuer will demand an offsetting hedge from GS&Co., as in currency warrants. 3. Need to price warrant at over $5.00 to allow short sales.

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			4. Filing and legal costs.
Sell to retail clientele	Sell to institutional clientele	1. Consumer preferences. 2. Expected profits higher selling to retail.	1. Requirement for retail sales force—possibility of loss of proprietary information to rivals. 2. Need small lot size (put on fraction of the Nikkei).
Sell and trade in American	Sell elsewhere	1. Consumer preferences/ demand	1. Timing differences between New York and Tokyo. 2. Either investor takes risks of price moves until next day, GS&Co. takes the risk of price moves while market is closed, permit investor limited contingency, or severely limit hours traded in New York.
Extraordinary Events Clause	No extraordinary events clause	1. Production requirement—Nikkei linked bonds have similar clause. 2. Production requirement—Hedging impossible or costly.	2. Meets production requirement

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Exhibit TN-3

GS&Co.'s dollar profit or loss at exercise from selling on NPW.

		Movements in Nikkei from current level of 38,586.18 ¥			
		Nikkei falls to 30,000¥		**Nikkei rises to 40,000¥**	
Movements in exchange rate from current level of 144.28¥/$	Exchange rate to 150¥/$ ($ appreciates)	GS&Co. Receives[a]	$11.45	GS&Co. Receives	0
		GS&Co. Pays[b]	11.90	GS&Co. Pays	0
		Net Loss	**($0.45)**	**Net Profit**	0
	Exchange rate to 140¥/$ ($ depreciates)	GS&Co. Receives[c]	$12.27	GS&Co. Receives	0
		GS&Co. Pays[b]	11.90	GS&Co. Pays	0
		Net Profit	$ 0.36	Net Profit	0

a. Receives from trading and arbitrage .2 x (38,586.18 - 30,000)/(150¥/$) = $11.45
b. Pays the Kingdom of Denmark .2 x (38,586.18 - 30,000)/(144.28¥/$) = $11.90
c. Receives from trading and arbitrage .2 x (38,586.18 - 30,000)/(140¥/$) = $12.27

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Exhibit TN-4

Cost to produce floating-rate yen-denominated Nikkei put warrants

Inputs		
Level of the Nikkei	¥38,486.18	(Case, **Exhibit 6**)
Dividend Yield on Nikkei	.49%	(Case, **Exhibit 6**)
Japanese Risk-free rate	5.85%	(Case, **Exhibit 6**, expressed on bond-equivalent-yield basis)
Volatility	13.6%	(Case, text)
Exercise price	¥38,486.18	(Case **Exhibit 4**, put will be at the money at issue)
Exercise period	3 years	(Case, **Exhibit 4**)
Valuation		
Eurpoean Put on Nikkei	¥1270	
on 1/5 of Nikkei	¥318	(Warrants written on one-fifth of Nikkei)
in US$	$1.76	(using current exchange rate of ¥144.284/$ from case, **Exhibit 6**)
American Put on Nikkei	¥1865	(Binomial model with constant dividend yield)
on 1/5 of Nikkei	¥373	(Warrants written on one fifth of Nikkei)
in US$	$2.59	(using current exchange rate of ¥144.284/$ from case, **Exhibit 6**)
Premium of American over European Put	47%	

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Exhibit TN-5

Cost to produce and market fixed-rate yen-denominated NPW

Variable Costs	Per Warrant	For 9.5M Warrants
Cost to manufacture floating-rate, at-the-money, 3 year American-style NPW at volatility of 13.6%	$2.59	$24.6 million
Cost to purchase QUANTOS currency hedging	$1.00	$ 9.5 million
Selling commissions	$0.32	$ 3.0 million
	$3.91	$37.1 million
Fixed Costs		
Payment to Kingdom of Denmark[a]		$1.3 million
Sunk Costs		
Legal and other fees		$.35 million
Product Development Time (ten person years at ?)[b]		$2.5 million

a. Assumes agreement between GS&Co. and the Kingdom of Denmark fixes payment for up to 9.5 warrants issued. It is possible that this contract may have been written with the fee conditional on the number of warrants sold.

b. This guess of the "shadow values" of ten-person years is pure speculation by the casewriter. The instructor may want to engage students as to how to cost out attempts to create new products that ultimately fail, but which produce information leading to the production of subsequent, more successful products.

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Exhibit TN-6

Implied Volatility of BT Bank of Canada NKP.WT on December 18, 1989

NKP.WT is a floating rate NPW whose value at exercise or expiration is determined by the following formula:

Cash settlement value = .1168 x (32,174 - NIKKEI)/(¥/C$ at exercise)

Therefore, it can be thought of as .1168 puts on the Nikkei sold in the domestic Japanese market, with a price today translated at the current exchange rate. Given the trading price of NKP.WT, one can back out the implied volatility of this American-Style put.

Inputs		
Level of the Nikkei	¥38,486.18	(Case, **Exhibit 6**)
Dividend yield on Nikkei	.49%	(Case, **Exhibit 6**)
Japanese risk-free rate	5.85%	(Case, **Exhibit 6**, expressed on bond-equivalent-yield basis)
Exercise price	¥32,174	(Case, **Exhibit 5**)
Exercise period	26 months	(Case, **Exhibit 5**)
Price of warrant in Yen[a]	C$ 2.61	(Case, **Exhibit 5**)
	¥324.63	($2.61 x 124.28¥/C$)
Price of one put in Yen[b]	¥2779	(¥324.63/.1168)
Implied volatility[c]	32.6% per annum	

a. Payoff to holder is exactly the same as payoff to Canadian purchaser of NPW sold in Japanese market, so translate price into Yen using current exchange rate.

b. Warrant is equivalent to .1168 Puts on the Nikkei.

c. Using binomial model to estimate value of American-style put on asset paying a constant dividend yield.

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Exhibit TN-7

Critical pricing levels for GS&Co. NPW issue

Costs		
Variable cost per NPW	$3.91	(See **Exhibit TN-5**)
Average cost per NPW	$4.04	(Variable cost plus fixed costs allocated over 9.5M warrants)
"Fully Loaded" Costs[a]	$4.34	(Average costs plus sunk cost allocated over 9.5M warrants)
Prices of Comparable Products		
Canadian experience[b]	32.68% volatility	
Price of US NKP if:		
Fixed rate feature not valued by consumers[c]	$8.52	
Consumers pay GS&Co. for fixed rate feature at cost[d]	$9.52	

a. This cost figure includes amortized sunk costs.

b. See **Exhibit TN-6** .

c. Assuming U.S. consumers willing to pay 32.6% volatility, and pay no premium for fixed-rate currency feature.

d. Assuming U.S. consumers willing to pay 32.6% volatility, and pay $1.00 for fixed-rate currency feature, i.e., willing to pay GS&Co.'s hedging costs.

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Exhibit TN-8

U.S. Exchange Traded Nikkei Put Warrant Issues

Comparison of Terms

Listing Date	Issuer	Lead Manager	AMEX Symbol	Number of Warrants	$U.S. Strike Price	Nikkei Strike Level (Yen)/Divisor[a]	¥/$US Exchange Rate	Issue Price	Expiration Date	Comments
Jan.12, 1990	Kingdom of Denmark	Goldman Sachs	DXAWS	10,350,000	$51.63	37,516.77/5	145.325		Jan. 3, 1993	American-style Fixed Yen/$US exchange rate
Jan.12	Tranche A			6,500,000				$4.05 (7.85% Premium) 19.73% vol.		
Jan. 17	Tranche B			3,850,000				$5.375 (10.41% premium) 22.98% vol		
Jan. 17, 1990	Salomon Inc.	Salomon Brothers	SXAWS	13,800,000	$50.61	36,821.14/5	145.52	$3.54 (7.00% premium) 18.25% vol.	Jan. 19, 1993	American-style Fixed Yen/$US exchange rate
Feb 1, 1990	Bankers Trust	Merrill Lynch	BTBWS	6,000,000	Fluctuates	37,206.42/2	Floating Rate	$9.17) (7.125% premium 18.50% vol	Jan. 16, 1993	American-style Fixed Yen/$US exchange rate
Feb. 23, 1990	Salomon Inc.	Salomon Brothers	SXOWS	9,000,000	$51.85	37,471.99/5	144.55	$3.76 (7.25% premium) 18.65% vol	Feb. 16, 1993	American-style Fixed Yen/$US exchange rate
April 18,1990	Paine Webber Group Inc.	Paine Webber	PXBWS	7,000,000	$36.61	29,249.06/5	159.80	$3.20 (8.75% premium) 21.90% vol.	April 8, 1993	American-style Fixed Yen/$US exchange rate
April 26, 1990	A/S Ekspor-finans	Goldman Sachs	EXWWS	7,500,000	$37.05	29,424.58/5	158.84	$3.75 (10.12% premium). 24.28% vol	April 22, 1990	American-style Fixed Yen/$US exchange rate

a. formula: $\frac{\text{(Nikkei Strike—Current Level)}}{\text{Divisor}}$—¥/$US Exchange Rate

Source: Goldman Sachs & Company.

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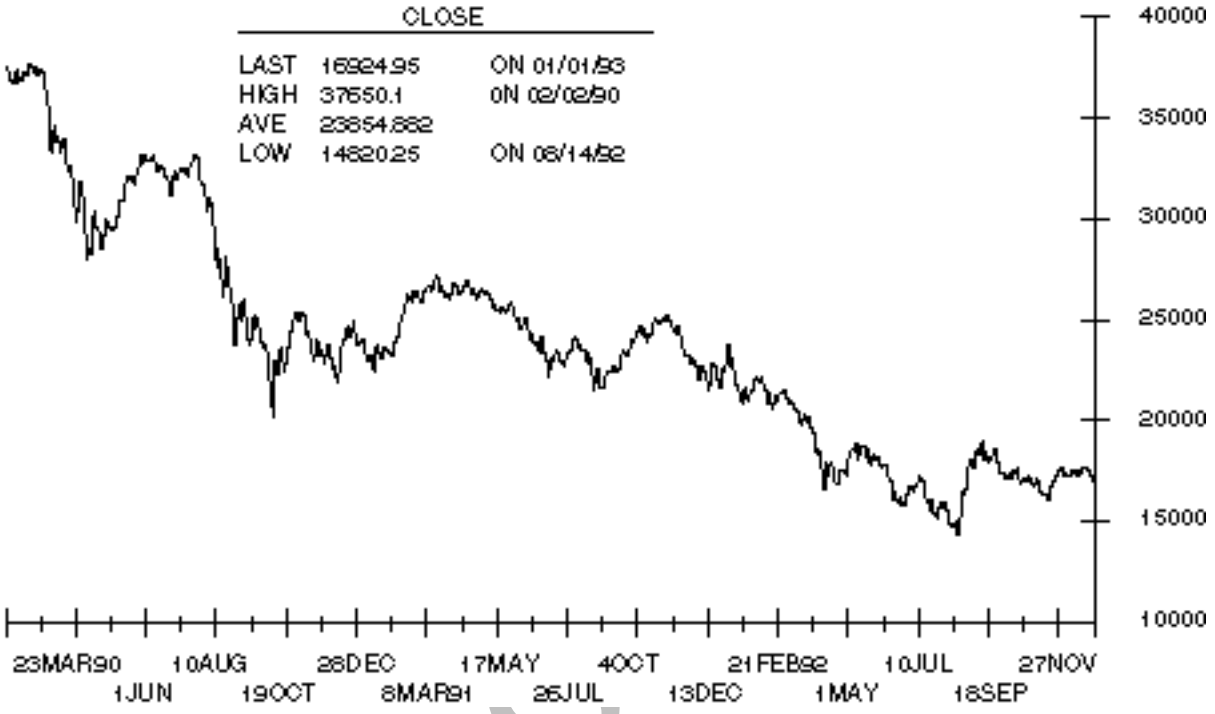
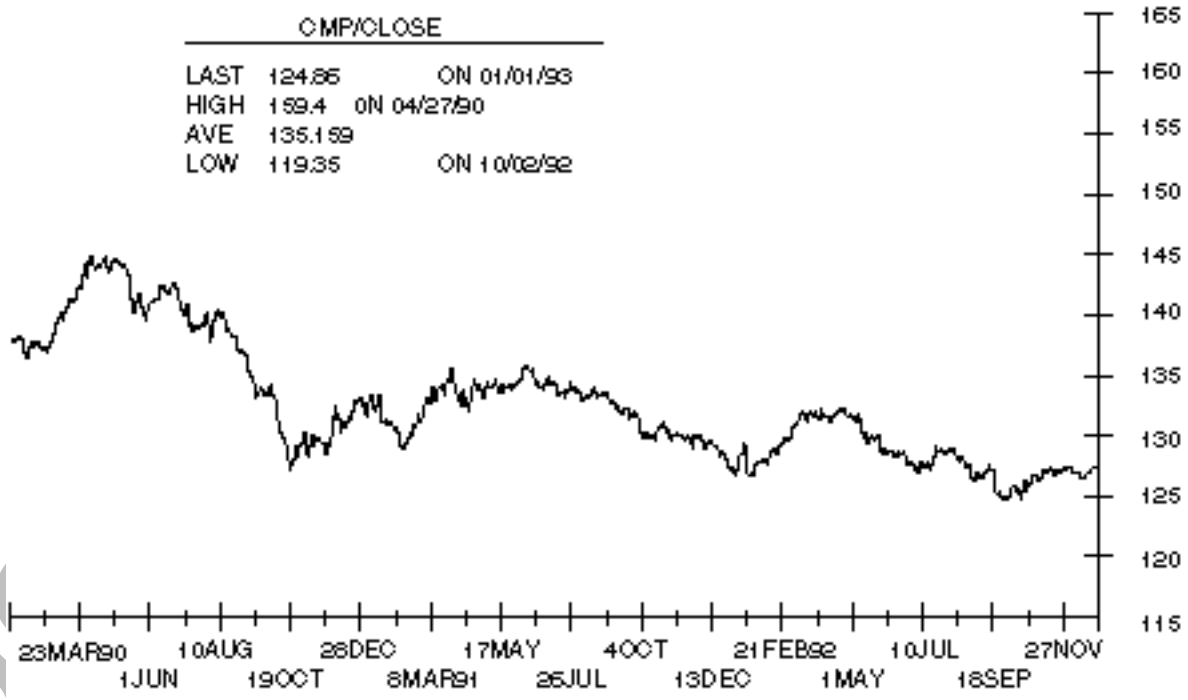
Exhibit TN-9

Level of the Nikkei 225 Index and ¥/$ exchange rate, January 1990-January 1993





Source: Bloomberg Financial Systems.

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Exhibit TN-10

Returns to initial purchasers of Kingdom of Denmark NPWs (if held to maturity), and net payoff to GS&Co. at maturity if no currency hedging put in place

Exchange rate fixed for NPWs:	¥145.325/$
Exercise price fixed for NPWs:	$51.63
Level of the Nikkei on January 3, 1993:	¥16,994
Exchange rate, January 3, 1993	125.35¥/$
Expiration value of Nikkei:	¥16,994/145.325 = $ 23.39
Payoff at expiration:	$51.63 - $23.39 = $28.24
Annualized return, if bought at $4.05:	91%
Annualized return, if bought at $5.375:	74%

Profits at maturity to GS&Co., if currency exposure not hedged.

Payoff to Kingdom of Denmark	$28.24
Payoff from Trading and Arbitrage	$32.75 = .2 x (¥37516.77 - ¥16994)/125.35¥/$
Net payoff at maturity assuming no currency hedge	$4.51

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