Convergence to Efficiency of the Nikkei Put Warrant Market of 1989-1990

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Abstract

This paper discusses the Nikkei put warrant market in Toronto and New York during 1989-1990. Three classes of long term American puts were traded which when evaluated in yen are ordinary, product and exchange asset puts, respectively. Type I do not involve exchange rates for yen investors. Type II fix in advance the exchange rate to be used on expiry in the home currency. Type III evaluate the strike and spot prices of the Nikkei Stock Average in the home currency rather than in yen. For typically observed parameters, Type I are theoretically more valuable than Type II which in turn are more valuable than Type III. In late 1989 and early 1990 there were significant departures from fair values in various markets. This was a market with a set of complex financial instruments that even sophisticated investors needed time to learn about to price properly. Investors in Canada were willing to pay far more than fair value for their puts. In addition, US investors overpriced Type II puts fixed in dollars rather than yen compared to Type I. This led to cross border and US traded (on the same exchange) low risk hedges. The market's convergence to efficiency took about one month after the introduction of the US puts in early 1990 leading to significant profits for the hedgers. The underreaction to this new information about cheaper nearly equivalent securities is analogous to that of the price delay of stocks to new earnings announcements.

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Introduction

The Japanese stock market now rivals that of the US in size and importance. Its growth in trading volume and capitalisation has been spectacular and recent. The markets in Tokyo, Osaka, Nagoya and five other regional exchanges that now trade were closed during World War II and then reopened in May 1949. Post war construction and aid by the US helped the Japanese economy grow quickly. By 1960, 9-% of the world's equity capitalisation was Japanese compared to 58% in the US, 27% in Europe and 6% in the rest of the world. By 1980 Japan had increased its share to 15% mainly at the expense of Europe whose share fell to 20%. The rest of the world doubled its capitalisation to 12% and the US still had the majority 53%. The 1980s were a period of economic excesses in the US that led to a weakening of the strong economic base held in 1980. The Reagan economic policies led to large deficits in both the overall budget and in trade, as well as large increases in military spending and debt payments. See Modigliani (1988) and Hatsopoulos, Krugman and Poterba (1989) for analyses. Meanwhile Japan maintained a policy of high investment in plant and equipment and R&D, financed through policies that emphasised and rewarded high savings. Company expansion proceeded more through debt and retained earnings than equity. Debt was readily available and was at low interest rates particularly through banks in the same industrial grouping (keritsu).

The 1980s were very financially favourable for Japanese firms. The combination of low interest rates, easy access to funds, strong export marketing expertise, emphasis on quality, access to foreign markets while maintaining structures and rules making imports to Japan difficult, led to an enormous relative wealth transfer from the US to Japan. By December 1988, Japan's equity capitalisation was 44%, Europe's 21%, the rest of the world's 6%, and the US fell to 29%. After the 1990-92 stock market decline, Japan's share fell to 25% as of September 1992. The US was then 40%, Europe 25% and the rest of the world 6%.

French and Poterba (1991) and Ziemba and Schwartz (1991), have argued that to properly measure capitalisation, one must adjust for company cross holdings. If company A holds much of company B's stock and vice versa, then the true market capitalisation of A plus B is less than the sum of the individual capitalisations. Japan and many of the European economies such as Germany and Italy have extensive cross holdings. About 71% of Japan's equity is cross held and rarely, if ever, traded. Calculations show that the capitalisation of Japan is overstated by about 25% (see for example, McDonald (1989)). After such adjustment, the share's in 1988-89 were about 39% for Japan, 33% for the US, 22% for Europe and 6% for the rest of the world.

Historically, Japanese stock markets have been much more influenced by foreign markets than the reverse as shown by Becker, Finnerty and Gupta (1990), Hamao, Masulis and Ng (1990) and Ziemba and Schwartz (1991). The transmission of mean returns and volatility was mostly unidirectional until the October 1987 world wide stock market crash. Since the crash, stock price movements in Japan have had more impact on those in New York and London. However, the reverse effect is much stronger, see for example, Hamao, Masulis and Ng (1991). It may be argued that this integration of capital markets is small because the Japanese markets are insulated to a large extent from foreign influence and are not deregulated.

Deregulation of Japan's financial markets began in earnest in 1987 with the introduction of the first equity index futures contract, the Kabusaki 50, which traded in Osaka. Futures on the Nikkei Stock Average had begun trading on the Singapore Monetary Exchange (SIMEX) in 1986. Bailey (1989) discusses the early history of these two futures contracts. In September 1988, trading began in futures contracts on the more popular Nikkei 225 stock average and the Tokyo stock price (Topix) index which were traded in Osaka and Tokyo, respectively. These contracts allowed foreign investors and institutions to easily hedge positions in Japanese equities and to engage more fully in a variety of types of programmed trading including index arbitrage and portfolio insurance. During 1988 and 1989, the Japanese equity markets increased dramatically in trading volume and market capitalisation. This was a period of cheap and easily available money for corporate and individual investors and speculators.

The equity warrant bonds issued in Luxembourg with the warrants trading in London was one such example. By adding the warrants which were stripped off and traded separately the bonds could offer low coupons. Hedging the proceeds of the bond sales, which were mainly in dollars, back into yen with its considerably lower interest rates, provided net costs at borrowing at close to zero percent. The equity warrants, when exercised several years later if they were in-the-money, provided an additional source of funds for the firm to pay off the bonds for a slight dilution. This market was in excess of $100 billion. See Mikami (1990), Takahashi (1990) and Kuwahara and Marsh (1992) for analyses of the pricing of these warrants.

Over-the-counter long-dated typically three year puts were marketed in 1988 by major non-Japanese brokerage houses to corporate clients who wished to hedge against long Japanese equity exposure or to speculate that the high priced Japanese stocks would eventually decline sharply. The sellers of these puts, which typically had premium value of $100,000 plus and were priced to trade at volatilities around 16-20% versus the historical 13%, were mostly large Japanese corporations. The corporations displayed a collective arrogance about the strength of the Japanese stock market and economy by generally not hedging. The high price earnings ratios in the 70 plus range and the astronomically high land prices typified by facts such as the Imperial Palace in Tokyo being worth as much as all the land in California led professional and amateur investors to believe that these high prices could not be sustained. See Aron (1981, 1989), French and Poterba (1991) and Stone and Ziemba (1993) for analyses. The first Japanese put warrants available to individual investors on an easily purchasable basis were the three year American-type Nikkei put warrants that traded on the Toronto Stock Exchange in February 1989. These puts were not true warrants as they were cash settled based on the price of the Nikkei Stock Average and were not exercisable into stock. Also their issuers were investment banks not individual firms. These warrants provided individual investors with the opportunity to bet against the high stock prices in Japan with a

minimal investment of capital. US investors were not allowed to purchase those warrants for three months and these warrants were not widely advertised and known outside Canada.

These warrants were purchased in such demand that their price in implied volatility was well above the historical for the NSA index. Most Canadian investors had no idea what the fair value was. The Toronto warrants were of three types: ordinary puts valued in yen, puts where the final exchange rate for yen is fixed in advance and puts where the NSA was evaluated in Canadian dollars.

This latter type allowed investors to profit from declines in the NSA or the Japanese yen or both. Although in principle straightforward to professionals as discussed in Sections II and III, below, besides being unable to evaluate the fair values of these warrants investors were unable to evaluate the relative differences between the various types of warrants. Thus, with complex instruments, even the most sophisticated in the market needed time to understand the products, price them fairly and invest in them to eliminate mispricings. The warrants also had different credit characteristics and when exercised were evaluated on the next days closing price of the NSA in Japan if there was trading that day otherwise on the next trading day. Investors exercising warrants could also put in the proviso that the warrant not be exercised if the NSA rose 500 or more points on the requested exercise day. In late 1989 the Type I and Type III Canadian NSA put warrants were greatly over-priced in comparison to fair values based on historical volatilities including that for the 1987 world wide stock market crash period. There was no way for a small investor to hedge these instruments. Large investors or institutions could, or course, hedge in the futures markets on the SIMEX or in Japan. Indeed this was the way that the issuers who sold the puts and were responsible for their exercise payments hedged their investment.

Grossman (1988) among others has argued that this is not a fully suitably approach because the futures synthetic does not have the same information requirements as the underlying derivative. Hence the same types of difficulties associated with the breakdown of portfolio insurance in the 1987 crash could possibly occur in this market as well. See Rubinstein (1988) for an analysis of the effect of portfolio insurance on the crash. A better hedge for investors was thus a negotiated over-the-counter put on the NSA that essentially matched the Toronto stock exchange traded warrants.

Such instruments were available in late 1989 from investment firms such as the Salomon Brothers and Bankers Trust. The authors and others were aware of the potential of shorting expensive Canadian NSA puts and hedging with a fair priced puts of similar characteristics and duration in another market. To short the Canadian put warrants these warrants needed to be borrowed since there was a fixed number of them issued. They also had to be shorted according to the uptick rule. This was more difficult than shorting an ordinary exchange traded put or call or an index option which is essentially from an infinite supply and does not have there restrictions. However, it was possible to short Canadian NSA put warrants in large numbers at the high implied volatilities. It was expected that the market price of these puts would drop to their fair value once a fairly priced product was easily available. Bankers Trust, the Salomon Brothers and the Kingdom of Denmark issued such warrants in January and February 1990. These warrants were all fixed exchange rate securities (of type II) except for the Bankers Trust January put which was a type I with a floating exchange rate.

Bernard and Thomas (1989, 1990), Affleck-Graves and Mendenhall (1992) and Aberbanell and Bernard (1992) have shown that there are considerable delays in the market price adjustment to new earnings announcements. Indeed some of these adjustments take several months to be fully reflected in market prices. Jacobs and Levy (1988) found that lagged earnings surprises are a declining but significant factor in security prices for one, two and three months after their announcement. The convergence of the NSA puts to efficiency were similar and the process took over one month from the time the first NSA put warrant was traded on the American Stock Exchange in January 1990. Large profits were made by hedgers, including the authors, although they took several risks that are difficult to quantify. Besides the credit and exchange rate risks (which could be hedged) there was a risk of forced buy-ins of the shorts at unfavourable prices because it was no longer possible to borrow the puts. All three of the authors had forced buy-ins for a small amount of their position. There was also a profitable hedge between fixed and non-fixed exchange rate puts that was affected by the absolute price of the puts. In all cases for the Nikkei puts and the Nikkei calls which are discussed in sections III to V fixed exchange rate options traded for prices above non-fixed exchange rate options when the theoretical price was less. Investors were willing to pay a premium to eliminate this exchange rate risk even though it could have been hedged much cheaper in the foreign exchange futures markets. Also investors paid a premium for low nominal priced warrants that is analogous to that of low priced stocks, see for example, Blume and Stambaugh (1983). This led to a hedge that was close to arbitrage where investors could sell the high nominal value but low implied volatility Bankers Trust warrants and purchase the higher priced Kingdom of Denmark and Salomon type A and type B warrants on the same exchange (the American Stock Exchange). These warrants were mispriced for the month of February 1990. Except for slightly different credit risk and strike prices these warrants were virtually identical. One of the authors used this near arbitrage to win the US stock market championship in the category of risk adjusted returns for accounts over one million dollars in 1990.

The paper is organised as follows. Section I contains a brief background to the Japanese stock market bracketing the time of this study (mid 1989 to mid 1990). Historical volatility is also discussed there. Additional references on the Japanese stock market include Elton and Gruber (1989), Amihud and Mendelson (1991), Chan, Hamao and Lakonishok (1991), Ziemba and Schwartz (1991, 1993), Ziemba, Bailey and Hamao (1991), Ziemba (1989, 1991ab), and Stone and Ziemba (1993).

Section II discusses the various NSA put warrants and call warrants that were trading in 1989-90 on the American and Toronto stock exchanges and categorises them into the three types which using the definitions in Rubinstein (1991) are ordinary, product and option to exchange. See also Donnelly (1990), Smith and Dunn (1990), and Tufano (1992) for general discussions of these warrants.

Section III provides a theoretical basis for comparing the three types of puts. Their values depend upon the NSA volatility as well as possibly the exchange rate volatility between the yen and the home currency (US or Canadian) and their interactions. Using typical parameter values it is shown that type I puts should be priced more than type II and in turn more than type III. This is in contrast to the actual pricing where the type II fixed exchange rate options traded for more than the ordinary type I puts during the study period. However, even though they were both overpriced in relation to historical volatility the type I and type III Canadian put warrants were correctly relatively priced by the market.

Section IV discusses the fair numerical valuation or the three types of puts using the Cox, Ross and Rubinstein (1979), Boyle (1988) and Boyle, Evnine and Gibbs (1989) two and three dimensional binomial lattice models. The three dimensional model is needed to evaluate puts that depend upon the NSA and the exchange rate. Other authors such as Clyman (1991, 1992), Gruca and Ritchken (1991), Chen, Sears and Shabrokhi (1992) have also discussed the pricing of the US Nikkei puts, particularly the type II fixed exchange rate type puts.

Section V discusses the put warrant hedge and the convergence to efficiency of the two mispriced markets: the Canadian versus the US and the US fixed versus non-fixed exchange rate puts. Relative option costs for fixed NSA volatility and exchange rate volatility as well as implied volatility comparisons are made. The preference for fixed exchange rate options which applied to puts also applied to calls which began trading in April 1990. The mispriced securities we discuss are referred to as hedge candidates although in some cases they are close to arbitrage. Classical index arbitrage is actively pursued in Japan especially by the foreign firms, see for example Miller (1992). Discussions of the potential profitability of such arbitrage appears in Brenner, Subrahmanyam and Uno (1989, 1990), Brooks and Yamada (1990), Lim (1991), Chung, Kang and Rhee (1992) and Ziemba and Schwartz (1993).

Section VI briefly discusses the relationship between the NSA put warrant prices in North America and the next day's cash market in Japan. With deep in-the-money options, the put discount or premium signalled the up or down direction of the NSA on the next day in Tokyo. For a small data set the conclusion is that the signal was correct in almost all cases. This is consistent with the conclusion that futures hedging of these instruments had a strong effect on the Japanese stock market. Gruca and Ritchken (1991) have also noted similar behaviour on the opening prices in Japan. A discussion of implications of the findings and concluding remarks appears in section VII.

I The Nikkei Stock Average 1949-1992 and its Historical Volatility

The NSA is a price weighted average of 225 large capitalised stocks traded on the Tokyo Stock Exchange. It is defined as

$$NSA_t = \sum_{i=1}^{225} \frac{Pi}{D_t} \quad \text{where } D_t = \text{divisor at time t.}$$

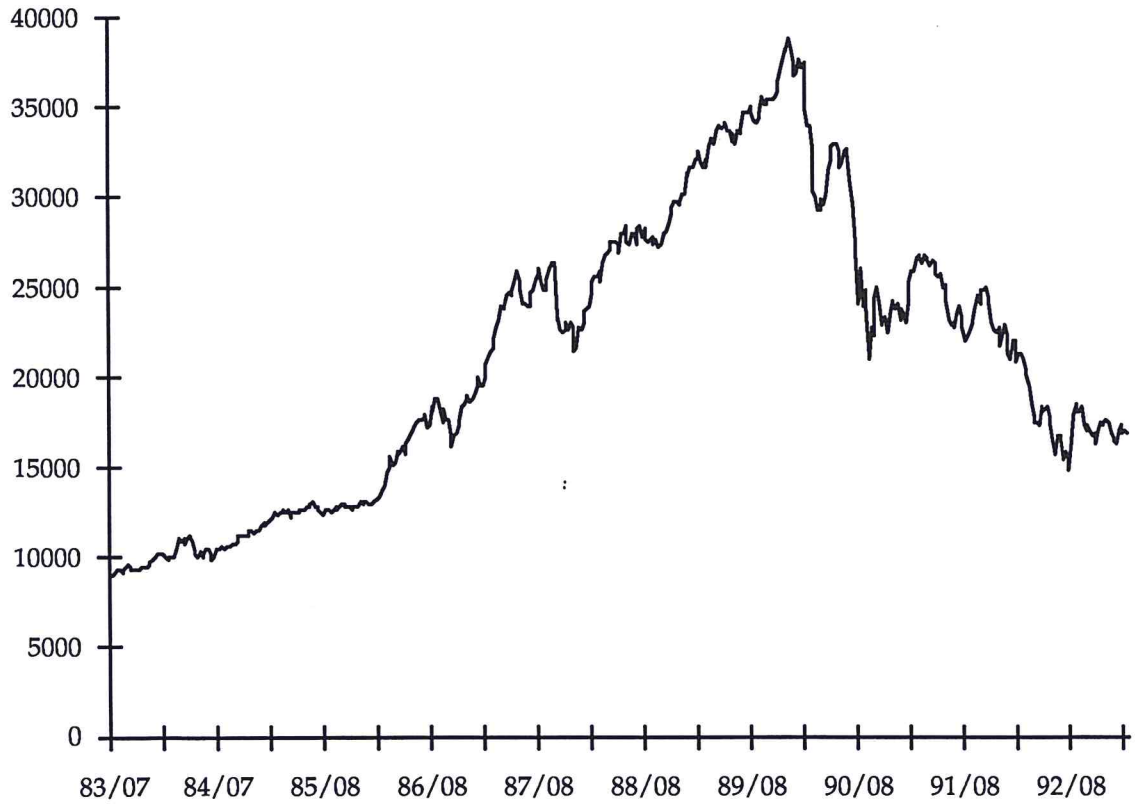
The original divisor was $D_{1949} = 225$ and $D_{1992,\,Dec} = 9.967$. Figure 1 shows the NSA from July 1983 to the end of February 1993. The NSA was 109.9 when it began trading in May 1949. It peaked at 38,916 at the end of December 1989. There were twenty declines of ten percent or more during 1949 to 1989. The index rose 220.84 times in yen and 553.04 in dollars from 1949 to 1989. There were nine declines of ten percent or more during 1990-92.[1] The index fell to 16,925 at the end of 1992 a decline of 56.5% since the December

1 A decline is defined as the peak to valley when the fall exceeds ten percent and any subsequent rise would invalidate the ten percent fall.

1989 high. Investors from 1949 still had 96.21 for each yen invested and 277.53 for each dollar invested. The 1990-92 decline had its minimum of 14,309, a decline of 63.2% from the December 1989 peak, on August 17, 1992. There is a very active index arbitrage market in the NSA which has been studied by Brenner, Subrahmanyam and Uno (1989, 1990), Miller (1992), Chung, Kang and Rhee (1992) and others. The value of the futures volume on the NSA trading in Singapore, Osaka and Chicago is the highest of any equity index in the world.

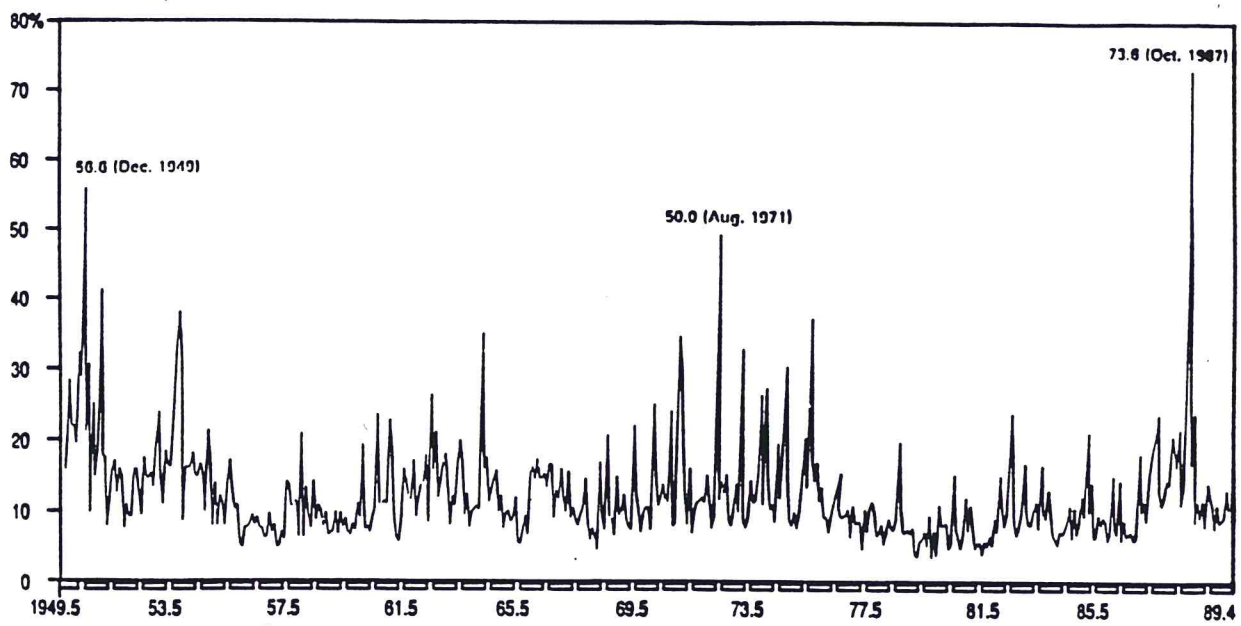
The press called the stock market decline during 1990-92 the bursting of a speculative bubble. French and Poterba (1991) among others pointed to the very high Japanese stock prices with price earnings ratios of seventy or higher in 1988-89. Stone and Ziemba (1993) have analysed the steep rise in the stock and land markets during the 1980's in the era of cheap and readily available money and the subsequent steep decline largely caused by the Bank of Japan's tight money policy of raising interest rates and decreasing the supply of money. They concluded that the decline in the stock market can be explained as an adjustment to changing fundamentals. Speculative land such as the membership prices of golf courses and condominiums, on the other hand, appears more likely to have been a speculative bubble. Table 4 below points to the high stock prices relative to past levels at the end of 1989.

Figure 1
The NSA July 1983 - February 1993



This paper studies the period mid-1989 to mid-1990. During 1989 historical volatility was in the 10% range or slightly below its 1949-1989 average of 13%. Volatility has not been constant. Figure 2 shows the monthly averages of daily volatility from May 1949 to April 1989. While volatility peaked at 73.5% in October 1987 most of the time the annualised standard deviation was less than 20%. Volatility tends to rise in declining markets, see Schwert (1989) and Turner and Weigel (1992), and the 1990-91 period in Japan had historical and implied volatilities in the 30-60% range for much of this period as shown in Figure 3.

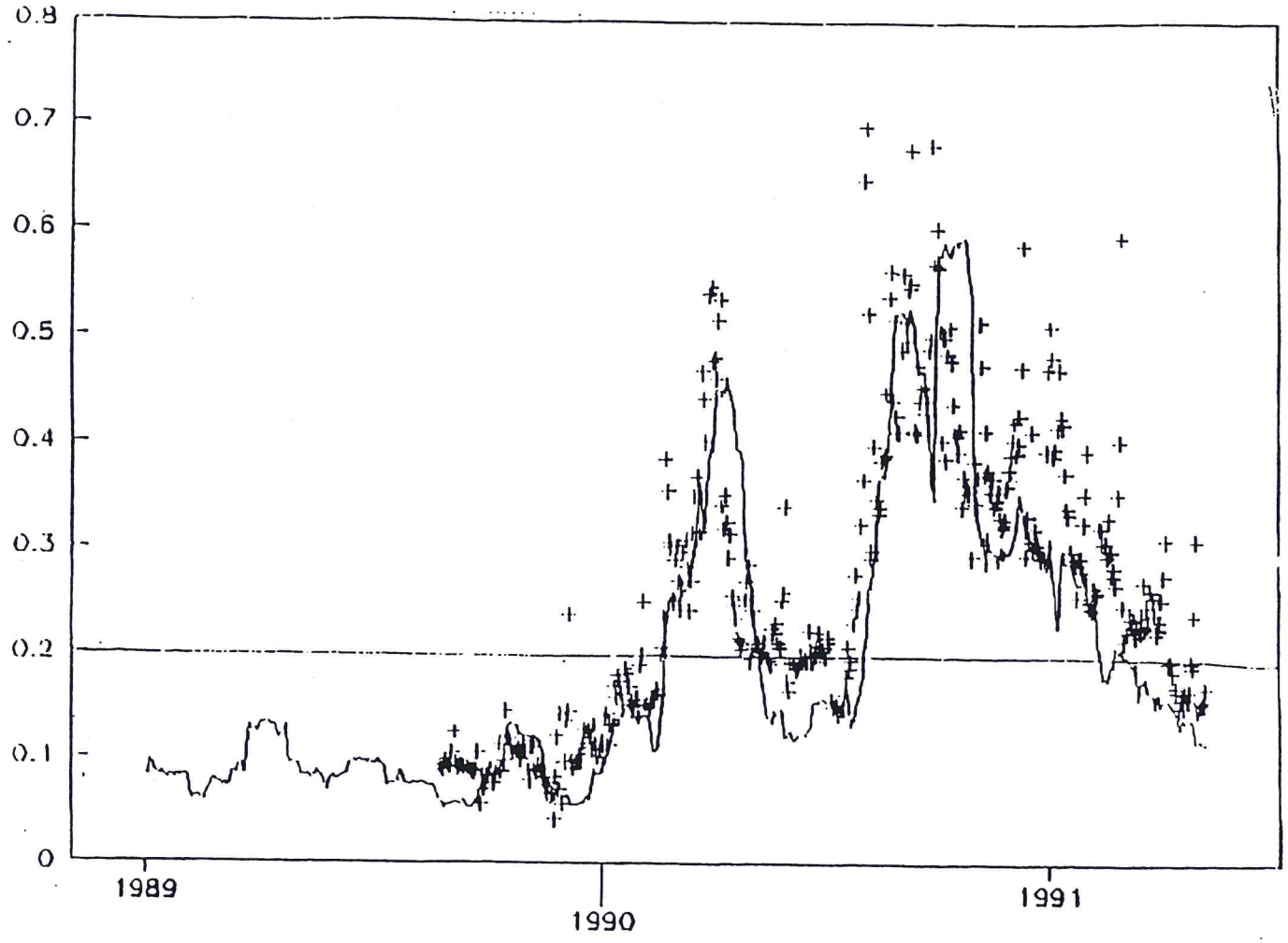
Figure 2
NSA Historical Volatility Monthly Averages of Daily Data Annualised
May 1949-April 1989



Source: Jun Uno, Nihon Keizai Shinbum, Inc.

The annualised volatility was computed using $\sigma = \sqrt{\frac{250}{20}\sum_{i=1}^{20} r_i^2}$ where $r_t = 100 \ln\left[\frac{NSA_t}{NSA_{t-1}}\right]$ for the last 20 trading days of the month and NSA_t, is the closing value of the NSA on day t assuming there are 250 trading days per year.

Figure 3
Historical and Implied NSA Volatility 1989-1991



--- Trailing 21-day historical volatility + Osaka Implied Volatility

Implied volatility is the average of closest to money NSA puts and calls for the nearest month using the Gensaki as the interest rate.

Source: Baring Securities

II NSA Put Warrants on the Toronto and American Stock Exchanges 1989-1990

The three year American style NSA put warrants are of three basic types. Let NSA_0 be the strike price and NSA_e the expiry price of the Nikkei stock average in yen. Let E_0 be the current exchange rate and E_e be the exchange rate on expiry for Canadian or US dollars into yen. The symbol (X)+ means the greater of X or zero. Then in yen we have using Rubinstein's (1991) classification of exotic options, where a, b, and c are constants.

	Value on Expiry	Type of Put	Currency Risk in U.S./Canadian Dollars
I.	$a\,[NSA_0-NSA_e]_+$	Ordinary	Yes
II.	$b\,[NSA_0-NSA_e]_+\ \frac{E_e}{E_0}$	Product	No
III.	$c\left(\frac{NSA_0}{E_0}-\frac{NSA_e}{E_e}\right)_+ E_e$	Option to Exchange	Yes, in index value and this difference with the strike price converted to the home currency

It is convenient to value the puts in yen as discussed in the next section. In their home currency (U.S. or Canadian dollars) using the symbols defined in Table 1, the puts (including the Paine Webber and Salomon calls) are:

		Puts	Calls
I.	$a\left(\frac{NSA_0-NSA_e}{E_e}\right)+$	BT-I, SEK, BTB, London OTC	PWA
II.	$b\left(\frac{NSA_0-NSA_e}{E_0}\right)+$	BT-III, BT-IV, TFC, DXA, EXW, SXA, SXO, PXB	Sal
III.	$c\left(\frac{NSA_0}{E_0}-\frac{NSA_e}{E_e}\right)+$	BT-II	

Each put warrant payoff function can be written as Lmax (strike-underlying, 0) Currency Units. That is L put options on the named underlying denominated in the specified currency unit. The actual payoff may be in different currency units converted at exercise or expiry at the exchange rate prevailing then. The warrants may be traded in different currency units. Neither of these affect the underlying put option, but its pricing changes. Thus the fixed characteristics of each warrant namely: the leverage factor (L), the strike price (X), the name of the underlying (Under), and the currency unit of the underlying (CU) places each of the warrants in the standard form shown in Table 1

Table 1
NSA Classification of Put and Call Warrants Trading in Canada and the US in 1989-90

Warrant	Payoff
Canadian Puts	
Bankers Trust-I(BT-I)	Cdn equivalent at rate then prevailing of yen 0.1168 (32174 - NSA)$_+$
Bankers Trust-II (BT-II)	Cdn 0.1031 (270.54-NSA$_t$/E$_t$)$_+$ where E$_t$ is the number of yen per Canadian dollar at exercise
Bankers Trust-III (BT-III)	Cdn \$2.50/7.25% (37460.00-NSA)$_+$/37460 = 0.0009205 (37460-NSA)$_+$
Bankers Trust-IV (BT-IV)	Cdn \$2.50/7.25% (29,843.34 - NSA)$_+$/29843.34 = 0.0011555 (29,843.34 - NSA)$_+$
Trilon (TFC)	Cdn \$2.75/7% (37416.32 - NSA)$_+$/37416.32 = 0.0010500 (37416.32 - NSA)$_+$
SEK	Cdn equivalent at rate then prevailing of yen 0.1168 (35963.74 - NSA)$_+$
US Puts	
Kingdom of Denmark (DXA)	US\$ 0.2 (37516.77-NSA)$_+$/145.33 = 0.0013762 (37515.65 - NSA)$_+$
Salomon-I (SXA)	US\$ 0.2 (36821.14 - NSA)$_+$/145.52 0.0013744 (36821.14 - NSA)$_+$
Bankers Trust (BTB)	US\$ equivalent at rate then prevailing of yen 0.5 (37206.42 - NSA)$_+$
Salomon-II (SXO)	US\$ 0.2 (37471.99 - NSA)$_+$/144.55 = 0.0013836 (37,471.99 - NSA)$_+$
Paine Webber (PXB)	US\$ 0.2 (29246.06 - NSA)$_+$ / 159.80 = 0.001252 (29246.06 - NSA)$_+$
Salomon Warrant OTC, London	yen 1.0 (32806 - NSA)$_+$
A/S Eskportfinans (EXW)	US\$ 0.2 (29,424.58 - NSA)$_+$ / 158.84 = 0.0012591 (29,424.58 - NSA)$_+$
US Calls	
Salomon (SXZ)	1/15 (NSA - 28,442.94)$_+$ 1/158.8 = .00041982 (NSA - 28,442.94)$_+$
Paine Webber (PWA)	US\$ equivalent at rate then prevailing of 1/10 (NSA - 29,249.06)$_+$

The various trading prices, currency of issue, strike prices, leverage values, expiry dates, implied volatility, 18% volatility price, relative cost (% above or below 18%, volatility price), 18% delta and intrinsic values for the various NSA put warrants are illustrated in

Table 2 for July 23, 1990. The basic data is NSA = 31895, Cdn$ = yen148.13, with interest rates of 11.75% Canadian, 7.361% US and 7.319% Japanese.

Table 2
Prices and Implied Volatilities of Actively Traded NSA Puts and Calls on the Toronto, American and London Over-the-Counter Stock Exchanges, July 23, 1990

Warrant	Type	Ask Price	Country of Issue	Leverage	Strike	Expiry	Currency	Implied Volatility	18% Vol Price	Relative Cost	18% Options Delta	Intrinsic Value
BT-I	Put	2.530	CAD	0.1168	32,174	17 Feb 92	JPY	23.9%	$1.76	44%	-0.40	$0.25
BT-II	Put	2.530	CAD	0.0011552	29,843	15 Jun 92	CAD	26.4%	$1.27	99%	-0.24	$0.00
BT-III	Put	6.500	CAD	0.0009203	37,460	4 Mar 93	CAD	29.3%	$5.15	26%	-0.90	$5.12
TFC	Put	8.000	CAD	0.0010487	37,460	22 Feb 93	CAD	32.7%	$5.87	36%	-0.90	$5.84
SEK	Put	4.000	CAD	0.1168	35,964	16 Nov 92	JPY	18.3%	$3.97	1%	-0.71	$3.71
DXA	Put	10.000	US	0.0013762	37,516	3 Jan 93	USD	29.9%	$7.78	29%	-0.90	$7.74
SXA	Put	9.000	US	0.0013744	36,822	19 Jan 93	USD	28.2%	$6.94	30%	-0.80	$6.77
SXO	Put	9.875	US	0.0013836	37,472	16 Feb 93	USD	29.0%	$7.78	27%	-0.88	$7.72
BTB	Put	20.500	US	0.5	37,206	16 Jan 93	JPY	23.8%	$18.16	13%	-0.85	$17.93
PXA	Put	3.125	US	0.0012516	29,249	8 Apr 93	USD	26.6%	$1.45	16%	-0.22	$0.00
PWA	Call	5.500	US	0.1	29,249	8 Apr 93	JPY	18.4%	$5.47	1%	0.84	$1.79
SXZ	Call	3.500	US	0.0004198	28,443	6 Apr 93	USD	15.4%	$3.61	3%	0.86	$1.45
Sal OTC	Put	28.50	US	1	35,750	21 Feb 92	JPY	19.2%	$27.62	3%	-0.74	$26.03
Sal OTC	Put	2.000	US	1	31,033	7 Aug 90	JPY	26.1%	$0.90	122%	-0.20	$0.00
Sal OTC	Put	9.25	US	1	28,139	19 Jan 91	JPY	29.9%	$2.75	236%	-0.14	$0.00
Sal OTC	Put	20.25	US	1	32,806	24 Apr 92	JPY	22.8%	$15.42	31%	-0.44	$6.15
Sal OTC	Put	35.74	DM*	1	36,969	26 Jun 91	JPY	22.7%	$34.26	4%	-0.99	$34.26
Sal OTC	Call	38.50	US	1	28,139	19 Jun 91	JPY	18.0%	$38.49	0%	0.87	$25.35
Sal OTC	Call	21.50	US	0.5	29,278	7 Apr 92	JPY	17.7%	$21.60	0%	0.82	$8.83

* The 36,969 Sal OTC put trades in Deutchmarks but is valued in US dollars.

III Numerical Comparison of Warrant Types I, II and III

The three types of warrant puts may be compared as follows. Assume that the American puts have a two year exercise period, the home currency is normalised at 1, the NSA is 100, the Japanese interest rate is 6%, the foreign (Canadian or US) interest rate is 10%, the NSA has a continuous yearly dividend of 0.5% and the standard deviation of the NSA is 20%. The relative values of the three types of puts vary with different assumptions on the volatility of the exchange rate and the covariance between the NSA and the exchange rate. It is assumed that the volatility of the exchange rate is 5, 10, or 20% and that the covariance of the NSA and the exchange rate is -0.5, 0.0 or 0.5. Table 3 contains fair values for these warrants in terms of percentage of the NSA.

Table 3
Comparison of Fair Values of NSA Put Warrants

a. Type I Volatility of the Exchange Rate

		5%	10%	20%
	-0.5	7.44	7.44	7.44
Cov (NSA, E)	0.0	7.44	7.44	7.44
	0.5	7.44	7.44	7.44

b. Type II Volatility of the Exchange Rate

		5%	10%	20%
	-0.5	7.36	7.57	8.00
Cov (NSA, E)	0.0	7.13	7.13	7.13
	0.5	6.95	6.77	6.42

c. Type III Volatility of the Exchange Rate

		5%	10%	20%
	-0.5	7.03	8.65	12.51
Cov (NSA, E)	0.0	6.02	6.78	9.51
	0.5	4.90	4.59	5.75

When priced in yen, Type I do not involve exchange rates, hence all warrant values are equal. With zero covariance between the NSA and exchange rates, the values of Type II warrants are the same regardless of the volatility of the exchange rates. This value is less than that for Type I warrants because of the positive differential between the foreign interest rate and the Japanese rate. However if the covariance is non-zero, then the value of Type II warrants depends both on that covariance and the volatility of the exchange rate. In general, the value of the warrant increases with the volatility of the exchange rate and for put warrants, decreases as the correlation increases. Positive correlation means that negative returns on the NSA are associated with a strengthening of the yen. The investor receives returns if the NSA declines so if this is accompanied by a stronger yen, the payoff is less at exercise than otherwise would be received.

Type III warrants have the most interesting behaviour. Their value depends on the volatility of the exchange rate even when the correlation is zero. In general, the higher the correlation, the lower the value of the warrant. With positive correlations, the value of the warrant for both low and high values of exchange rate volatility is higher than that for the intermediate. For typical observed parameters - covariance zero, exchange volatility about 10% and foreign interest rate above Japan's - Type I warrants are generally worth more than Type II warrants which are worth more than Type III warrants, all other parameters (leverage, strike price, time to expiration, etc) being equal. There is a similar relationship between the Type I (Paine Webber) and Type II (Salomon) calls; see Figures 9 and 10.

IV Fair Valuation of NSA Put and Call Warrants

All of the warrants involve the NSA index and are American type and are priced in yen and may involve an exchange rate. Boyle's (1988) generalisation of the Cox-Ross-Rubinstein (1979) binomial lattice model was used to create 3-dimensional lattices to model the evolution of the NSA and the exchange rate and their interaction over time. In terms of calculation steps for n time steps, the CRR is of order n^2 and Boyle's is of order n^3. The value of the option is the expected present value of the option payoff in an economy in which the drift of a risky asset is the risk-free rate minus its dividend yield. The discount factor used to calculate the present value of the payoff is the risk-free rate. For the dividend yield, we use the foreign interest rate. The NSA dividend yield during 1989 was about 0.5%. While most of the dividends are paid in March and September, see Ziemba and Schwartz (1991), the continuous approximation used is good because the yield is so small. We ignore the typical one day or longer time lag between giving notice of exercise and actually being cashed out and other special provisions of the warrants including the credit risk of the issuer.

Type I Put Warrants

The exercise value is Yen L Max [(X - NSA_t), 0]. The currency plays no role. At expiry one converts yen immediately into dollars. Hence one has a standard put option which may be valued on a CRR lattice in yen.

Type II Put Warrants

The exercise value is Yen L Max [(X - NSA_t), 0] E_t.

If the Cov (NSA, E) = 0 then the put is an American style on the NSA which may be valued on a CRR lattice.[2,3] Since the puts are American, lattice methods are required for accurate price evaluation. The interest rate used is that in the foreign pay currency. The dividend yield is replaced by the actual dividend yield on the index plus the interest rate differential. The currency risk may be hedged away by paying an extra dividend yield equal to the differential. By hedging into the foreign currency, the appropriate discount factor is the foreign risk free rate.

Type II warrants are generalisations of Type I warrants in that a Type I warrant is a Type II warrant for which the payout currency is yen.

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2 Data shows that Cov(NSA, \$Cdn/¥) ≅ 0 and Cov(NSA, \$US/¥) ≅ 0. If the Cov (NSA, E) _0, then one may value these puts on a CRR lattice by adjusting σ_{NSA} to $\sigma_{NSA} + \rho\, \sigma_{NSA}\, \sigma_E$ with the dividend yield equal to $d_{NSA} + r_{USA/Cdn} - r_{Japan}$; see Merton (1973) for proof.

3 A closed form solution exists for this product option in the European case assuming log normal NSA and log normal currency changes since the product of lognormals is lognormal; see e.g. Merton (1973). This is developed specifically in Gruca and Ritchken (1991) and Clyman (1991, 1992). The latter author also develops arbitrage relationships updating the Merton (1973) analysis to this case.

Type III Put Warrants

The exercise value is Yen L Max [(XE_t - NSA_t, 0]. These warrants are fundamentally different and only the Canadian BT-II is of this type. They have fair values above intrinsic even if the NSA has zero volatility and they may be valued as an option to exchange with a minor modification of Margrabe's (1978) formula. Two risky assets a, b with values S_a, S_b have

payoff = $\text{Max}(0, S_b - S_a)$
= $S_b \text{ Max } (0, 1 - S_a/S_b)$
= $S_a \text{ Max } (0, S_b/S_a - 1)$.

Thus an option to exchange may be regarded as a put on the value of S_a denominated in units of S_b or a call on the value of S_b denominated in units of S_a. Let s_α and σ_b be the volatility of a and b, respectively, and ρ be the correlation of the logs of the price relatives. Margrabe's formula requires the dividend yield to be zero in the Black-Scholes put and call pricing. Using the notation: pricing formula (option type)(asset, X,T,σ, Div B, Div A) asset,

BS put (S_a/S_b, 1, T, σ, 0, 0) S_a or equivalently BS call (S_b/S_a, 1, T, σ, 0, 0) S_b. where

$$\sigma = \sqrt{\sigma_a^2 - 2\rho\sigma_a\sigma_b + \sigma_b^2}.$$

In a risk neutral economy the drift of S_a and S_b is r, the risk free rate, thus S_a/S_b has drift of zero. Margrabe's formula can be extended to dividend paying assets with payoff X (S_b - S_a), where X is a constant as follows. Since S_a/S_b drifts at rate Div b - Div a where Div is dividend yield. The discount rate is Div b since the value is measured in units of S_b. The value of an American style option to exchange S_a for S_b is then S_bCRR (opt type, S_a/S_b, X, T, s, Div B, Div A). Hence the pricing is

L EX_t CRR (Put, NSA_t/E_t, X, T, σ, i_E , Div NSA).

V Put Warrant Hedge and Convergence to Efficiency

The various exchange traded puts in Canada and the US. and the over the counter puts traded in London had many common and several different characteristics that led to significant price differences. Reasons for the price differences from fair values include currency and cross border risks, different credit risks, difficulties with borrowing for short sales, price effects due to the differing size of the warrants, differing strike values, inability to value the warrants properly, differing exercise provisions, market sentiment and volatility differences. The London over the counter market was active in 1988 and 1989 for large institutional investors. Prices were quoted by the market makers based on historical volatility (in the 15% range) plus a profit margin. Salomon Brothers and to a lesser extent Bankers Trust, made the market with large bid ask spreads as shown below. On November 24, 1989, the NSA was 36,484 and three of the Salomon Brothers over-the-counter put warrants were priced as follows.

			Price in Dollars	
Strike	Expiry Date	Price in Yen	Nov 24, 1989	Oct 23, 1990
32 806	April 24, 1992	¥934-970	$6.50-6.75	$65.00
31,033	Aug 7, 1990	503-575	3.25-3.75	Expired
28,139	June 19, 1991	75.5-76.5	0.40-0.45	$39.50

By October 23, 1990, the puts had increased at least ten times.

The Canadian put warrants BT-I and BT-II were the first opportunity for non-institutional Canadian and US. investors (three months after issue) to profit from a fall in the Japanese stock market. BT-I was issued in February 1989 and BT-II in June 1989. These warrants were very popular with investors and traded for very high premiums and implied volatilities.

Table 4
Paul Aron's Adjusted PERs for Japan Compared with those in the US. April 26, 1981, to August 31, 1989 with Adjustments for Later Periods to February 22, 1991 by Ziemba and Schwartz (1991)

Date	US. PER	Japan, adj PER	NSA	
Apr 26, 1981	9.1	4.0	7548	
Oct 19, 1984	10.0	11.5	10929	
Apr 17, 1986	13.7	13.5	15827	
May 26, 1987	17.4	17.4	24533	
Sept 11, 1987	20.3	18.1	24829	
Dec 31, 1987	14.4	14.5	21533	
May 31, 1988	13.1	15.4	26963	
Aug 30, 1988	11.3	15.5	27679	
Aug 31, 1989	13.5	17.5	34808	
Dec 31, 1989	13.5	23.9	38915	
Mar 30, 1990	15.5	19.7	29980	
June 22, 1990	17.0	19.8	31694	= expensive
Sept 30, 1990	13.6	15.2	20,983	= cheap
Oct 1, 1990	14.3	13.5	20,022	
Oct 2, 1990	14.3	15.4	22,896	
Dec 31, 1990	13.6	14.8	23849	
Feb 22, 1991	16.2	14.9	25903	

Values after August 1989 assume:

	Interest		
	US	Japan	Earnings Gain over Aug 89
Dec 1989	8.2	6.4	5%
Mar 1990	8.4	7.4	10%
June 1990	8.2	7.0	12%
Sept 1990	8.2	7.75	8%
Oct 1, 1990	8.1	7.5	8%
Oct 2, 1990	8.1	7.5	8%
Dec 31, 1990	7.6	6.5	8%
Feb 22, 1991	7.6	6.0	8%

There was considerable good reason to believe that the Tokyo market was overvalued. See French and Poterba (1991) for one analysis based on adjusted price earnings ratios and Ziemba and Schwartz (1991) for a synthesis of various studies. One way to evaluate this is via Paul Aron's adjusted price earnings ratios which are comparable to French and Poterba's adjustments although somewhat lower. Aron (1981, 1989) computed these ratios to the end of August 1989. His values are shown in Table 4. His adjustments reflect different accounting and business practices, cross holding effects and different capitalisation rates. Ziemba and Schwartz (1991) updated Aron's adjusted values after August 1989 with assumptions concerning the earnings change of the NSA and capitalisation rates. The values are shown in Table 4 up to February 22, 1991. The December 31, 1989 value of 23.9 was the highest adjusted price earnings ratio at any time since 1949 and pointed to extreme risk in the stock market.

Despite its decline during 1990, it was not until the steep decline on October 1 that these values became *cheap* relative to historical price earnings ratios. Other stock market valuation models such as bond and stock yield differences, see Ziemba and Schwartz (1991), also were at historical high values at the end of 1989. All of these models are driven by two factors: earnings forecasts and interest rates. The extreme increase in interest rates in 1989 from a 2.5% discount rate to 5.25% and later to 6.0% was at the heart of the estimated overvaluation.

In a multivariate factor model regression study for the period 1979-1989, Ziemba (1989) found that future earnings forecasts were by far the most important variable for predicting the rates of return of Japanese stocks.

Hence there was considerable reason for investors to believe that the Japanese market would crash or at least decline sharply. Since the Canadian puts were the only product available to invest in this belief, their prices were understandably very high, particularly given that it was difficult for nearly all of the purchasers of these puts to fairly value them. Seasonality observers also noted that the decline in January 1990 while only 4.5% was a key negative signal since January has historically provided the highest returns in the Japanese markets, see Ziemba (1991b). Moreover, the conditional probability of a decline in the rest of the year following a decline in January is quite high; see Hensel, Sick and Ziemba (1993).

Table 5
Comparison of Prices and Premium Values for Four Canadian and Three US. NSA Put Warrants on February 1, 1990

Warrant	Price	% of NSA Unit	Expiry Date	Years to Expiry	% Premium	Premium per Year %	Hedging Actions	
BT-I	$2.70cdn	11.68%	2/17/92	2.05	20.1	9.8	SELL	
BT-II	$1.93cdn	10.31%	6/15/92	2.37	16.4	6.9	SELL	
BT-III	$2.50cdn	14.29%	2/16/93	3.05	7.0	2.3		
Trilon Finl	$2.75cdn	13.7%	2/22/93	3.05	7.25	2.4		
K of Denmark	$5.63us	20%	1/3/93	2.93	10.1	3.4		SELL
Salomon-I	$4.63us	20%	1/19/93	2.97	10.1	3.4		SELL
BT-US.	$9.17us	50%	1/16/93	3.00	8.0	2.6	BUY	BUY

Table 3 shows that the fair values of Type I warrants generally exceed those of Type II which in turn exceed those of Type III. The BT-I is a Type I and the BT-II a Type III. In terms of premium, see Table 5, the BT-I was priced higher than the BT-II. This was the case in the entire trading period from September 1989 to the eventual collapse in February 1990. Table 5 provides insight into pricing differences but those provided from theoretical option pricing models, as we now discuss, are used in our analysis. Figures 4 and 5 show the theoretical pricing in two ways. Implied volatilities appear in Figure 4. They illustrate the point. However, implied volatilities did not exist at many dates in 1990 when the puts were trading at discounts (as discussed later in the paper); see the vertical lines in Figure 4. Hence, a preferable way to compare the warrants prices is by their relative cost. That is actual cost minus theoretical value as a percentage of theoretical value. This is shown in Figure 5 assuming a volatility for the NSA of 20% and an exchange rate volatility of 10%.

There were no NSA put warrants trading in the United States until the Kingdom of Denmark (Type II) put warrant began trading on the American Stock Exchange on January 3, 1993. The Salomon A (Type II) and Bankers Trust (Type I) put warrants began trading two weeks later. With the availability of these three warrants investors in the Canadian put warrants could replace these warrants with the much cheaper US. instruments. Figures 4 and 5 show that it took more than a month for the Canadian puts to converge to efficiency. A gradual decline began with the introduction and market knowledge of the three cheaper US. instruments and then there was a sudden collapse in late February 1990 just after the second Salomon put warrant (a type II) began trading. The slowness of the market to react to new information is very similar to that of stock prices slowly reacting to new earnings information, see Affleck-Graves and Mendenhall (1992), Bernard and Thomas (1990, 1992) and Aberbanell and Bernard (1992). This shows that the market needs time to understand, evaluate and then fairly price some complex instruments.

The collapse occurred at a time of minor decline in the NSA in February 1990 well before the steep declines in March and April 1990. Hedge investors who were able to short the Canadian put warrants and buy cheaper US. warrants particularly the Bankers Trust BTB could have made considerable profits.[4]

A second advantageous hedge is illustrated in Figure 6. Despite the fact that the theoretical fair values of type I warrants is larger than type II, US. investors had a preference for type II instruments. Apparently they preferred a fixed exchange rate in dollars upon expiry rather than to value the puts in yen. To eliminate the currency risk, they paid more for type II warrants than if they had bought type I warrants and hedged the currency risk in the futures market. Hence type II warrants traded for prices which were much larger than those of the type I warrants. There was also a price effect. The BTB warrant represented 0.5 of an NSA unit and the DXA, SXA and SXOs were worth only 0.2 of an NSA. Hence the BTB should trade, other things being equal, at about 2.5 times plus or minus a transactions cost band around the other warrants. In fact the BTB usually traded at prices much less. This is analogous to the low priced stock effect, see Blume and Stambaugh (1983). These two factors yielded the profitable hedge from

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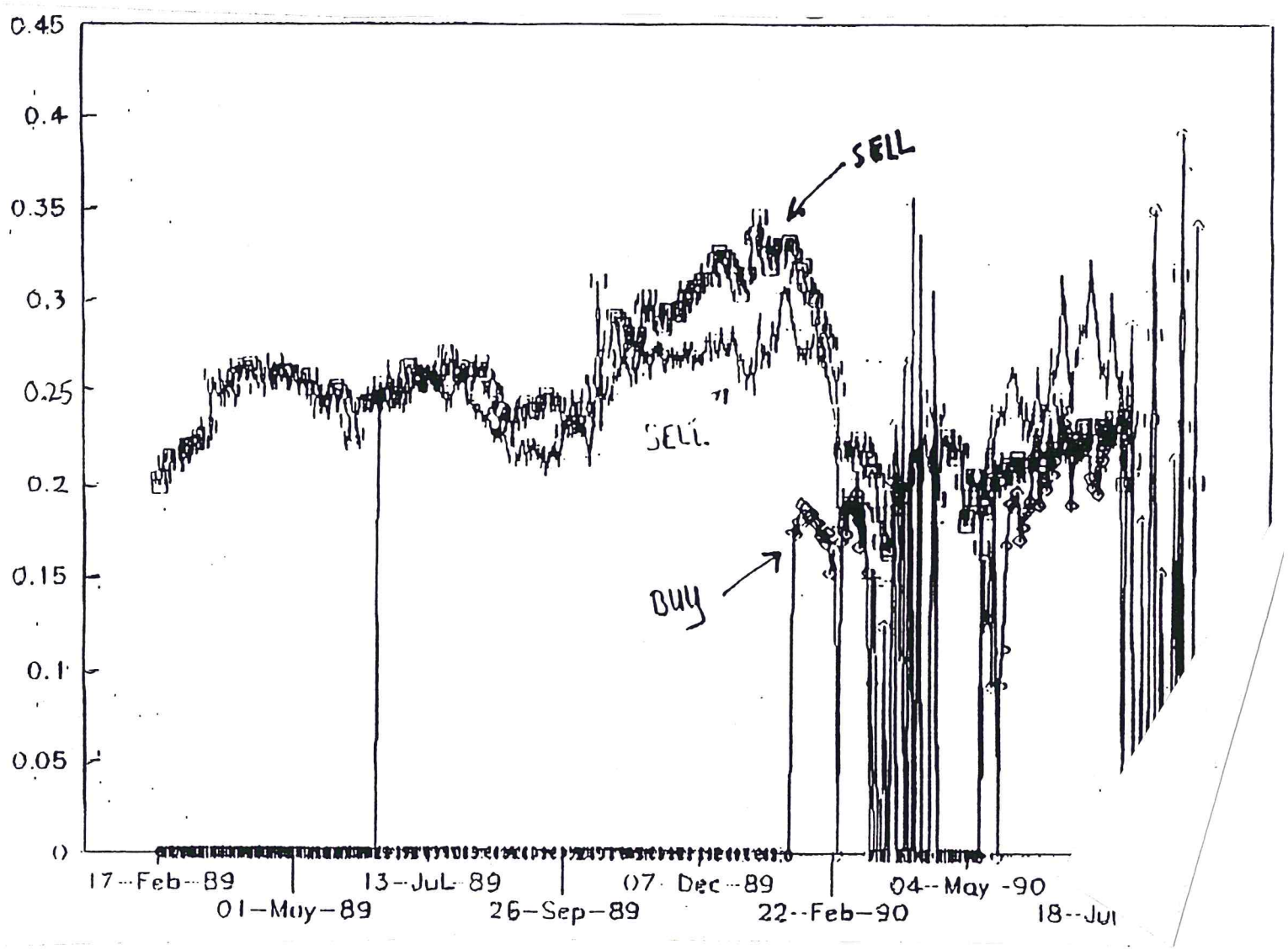
4 This hedge had relatively low risk but was not a true arbitrage given that there were different credit risks and other characteristics of the various put warrants. There was also the difficulty of securing and holding borrowed warrant short positions. The threat of forced buy -in was also present. All three authors did have forced buy ins of short positions, but the amount was small so that the overall hedge was very successful.

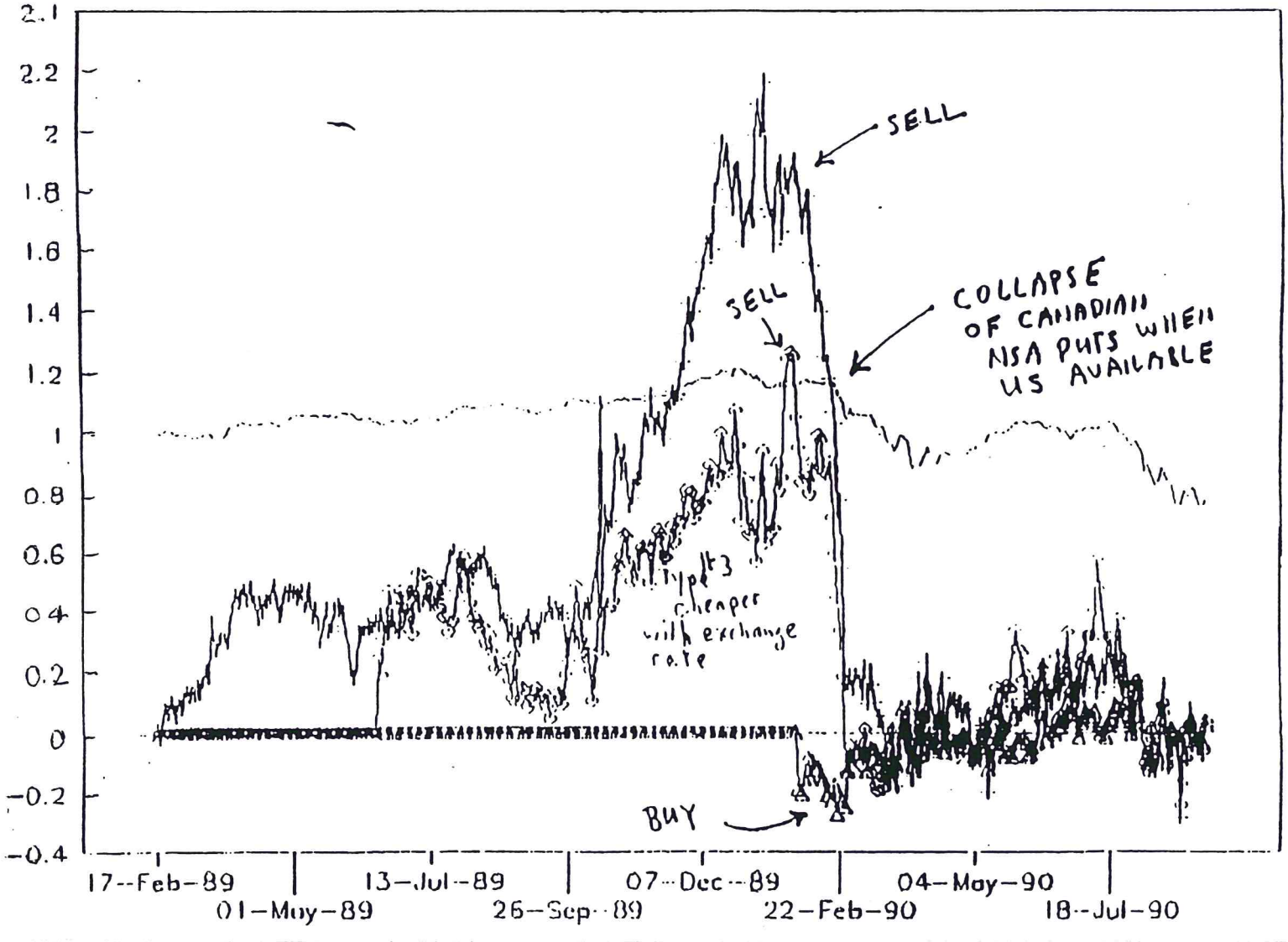
January to March 1990. After convergence to efficiency these markets have since generally traded within transactions costs bands.[5]

Figure 4
Implied Volatility of BT-I, BT-II, and BTB NSA Put Warrants Assuming Exchange Rate Volatility of 10%, February 17, 1989 to September 21, 1990



5 Additional analysis of the post March 1990 period for various US. NSA put warrants , particularly of type II, appears in Clyman (1991, 1992) and Chen, Sears and Shahrokhi (1992). Generally speaking after transactions costs are considered, the market was efficient.

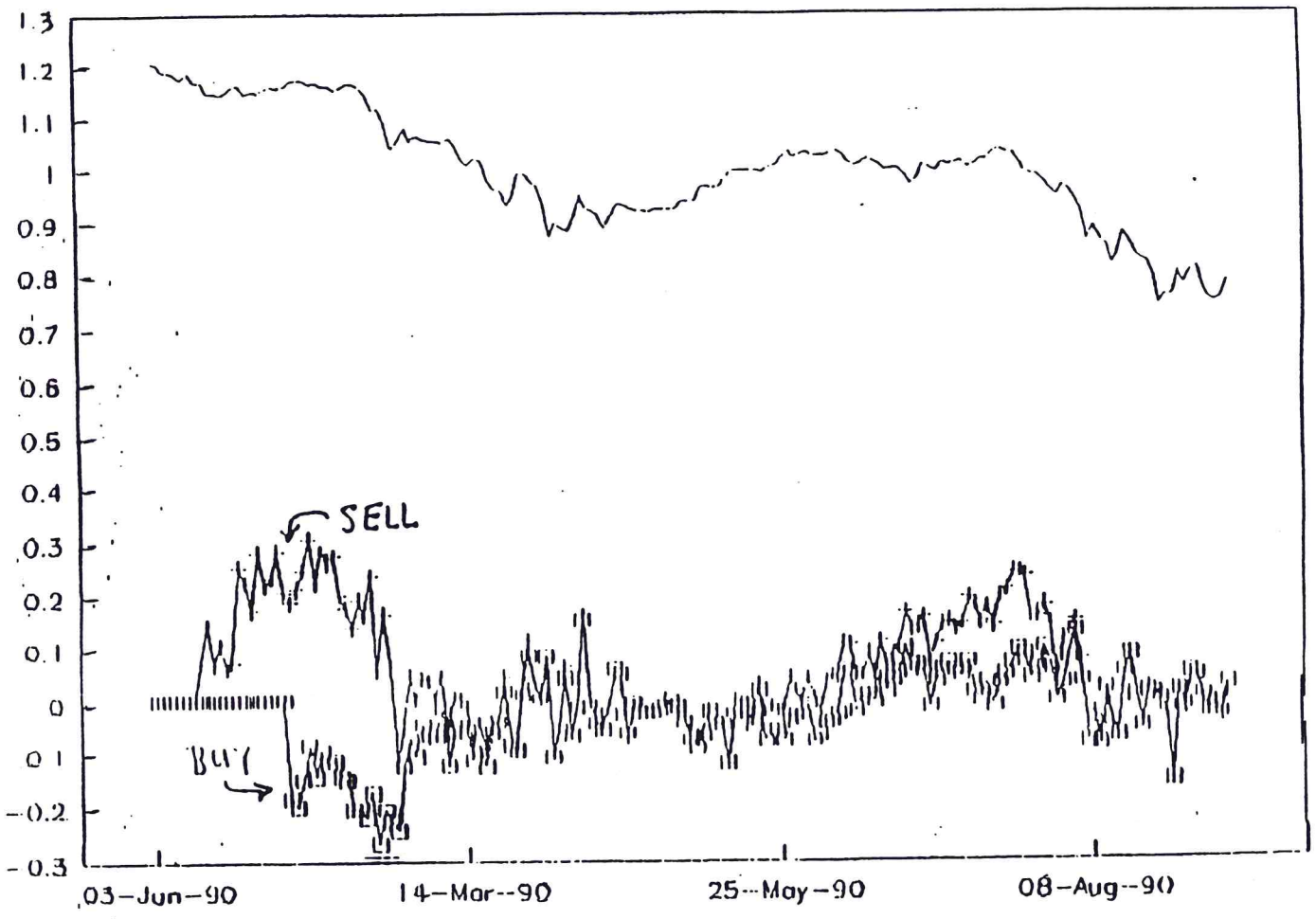
Figure 5
Relative Costs of BT-I, BT-II and BTB NSA Put Warrants with NSA volatility of 20% and Exchange Rate Volatility of 10%, February 17, 1989 to September 21, 1990.



$$\text{Relative cost} = \frac{\text{Actual Cost–Theoretical Value}}{\text{Theoretical Value}}$$

+ BT-I	◊ BT-II	Δ BTB
Type 1	Type 3	Type 1
Canadian	Canadian	US

Figure 6
Relative Cost of US. Type I (BTB) versus US. Type II (DXA, SXA, SXO) NSA Put Warrants, January to September 1990, assuming NSA Volatility of 20%



□ BTB Type 1 0.5 NSA + Avg DXA, SXA, SXO – Type 2 0.2 NSA Normalised Nikkei

Figure 7 shows the relative costs of various put warrants in Canada and the US. with similar strike prices. These warrants were all issued in early 1990 and had NSA strikes between 36,822 and 37,472. Here we see clearly the higher prices paid for type II warrants in comparison to type I from January to the end of February 1990.

Figure 7
Relative Costs Puts with Similar Strike Prices, assuming 20% NSA Volatility, Yen/Canadian Dollars Volatility of 10%, January to September 1990

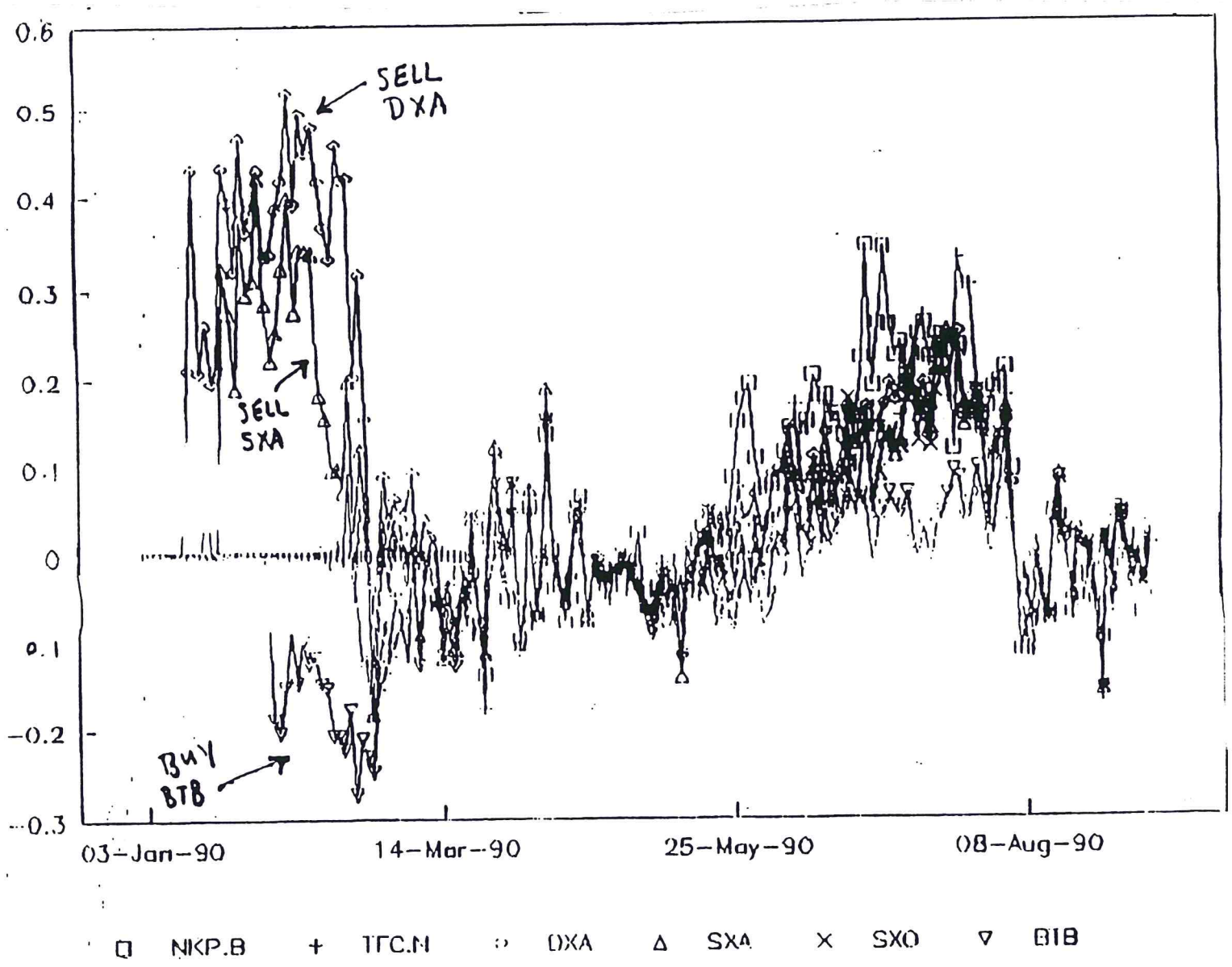
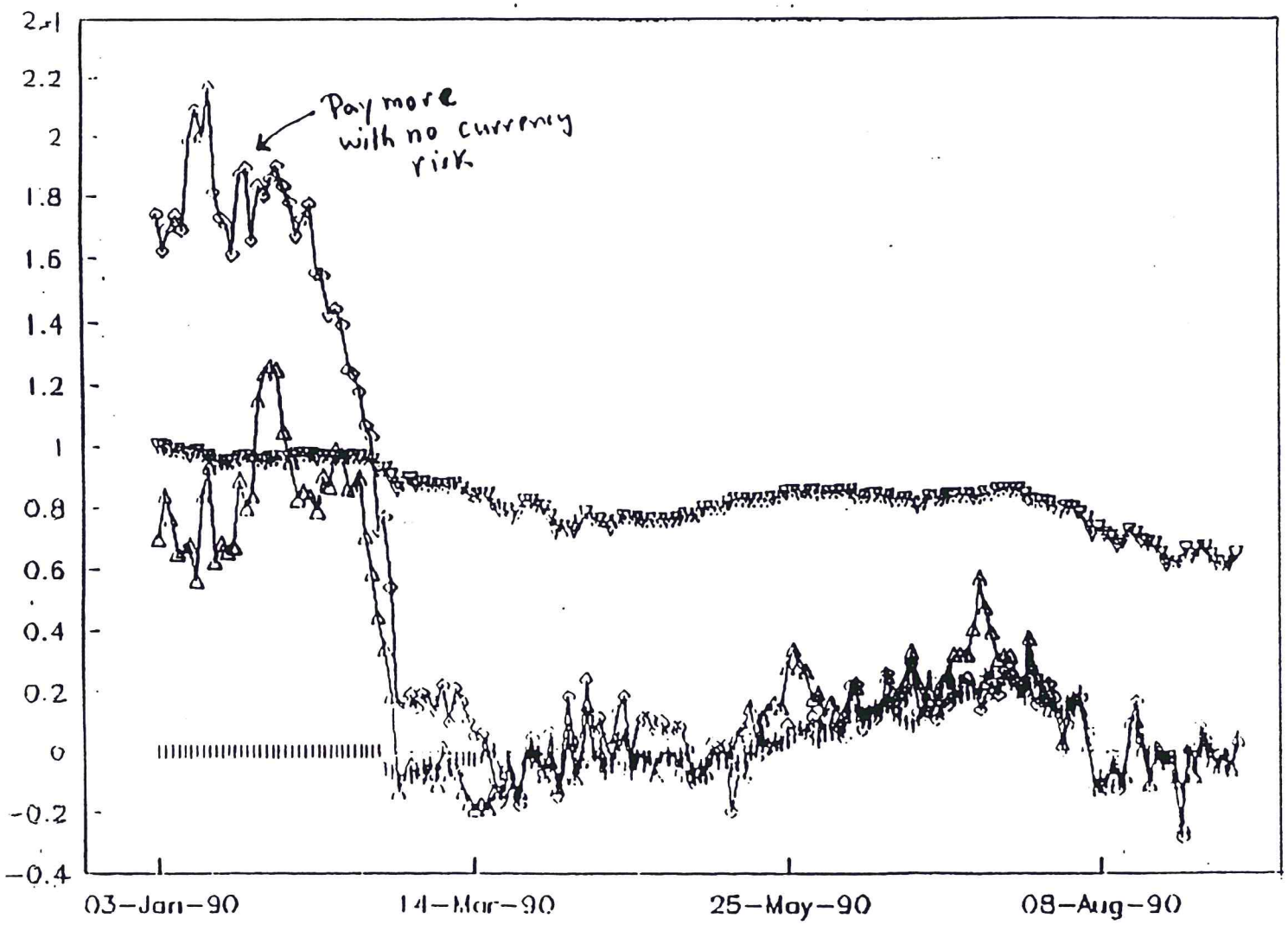


Figure 8 shows the relative costs of Canadian type I, II and III NSA put warrants. Investors, relative to fair prices paid more for type I (BT-I) than for type III (BT-II) until the market converged to efficiency in late February 1990. From March to September 1990, all three types of put warrants had relative costs within transaction cost bands.

Figure 8
Relative Costs of Canadian Type I, II and III Put Warrants based on 20% NSA Volatility and 10% Yen/Canadian Dollar Volatility, January to September 1990



+ Type II
Avg BT-III, TFC
SEK no Volume

◊ Type I
BT-I

Δ Type III
BT-II

∇ Normalised Nikkei

Figures 9 and 10 give the implied volatilities and relative costs of the two NSA call warrants traded on the American Stock Exchange. The Paine Webber call is a type I and the Salomon is a type II. The fair value of a type I should be higher than a type II. However, US. investors preferred the Type II with its fixed exchange rate of dollars into yen and bid its price higher during most periods from April to October 1990.

Figure 9
Implied Volatility of the Paine Webber and Salomon NSA Call Warrants, April to October 1990

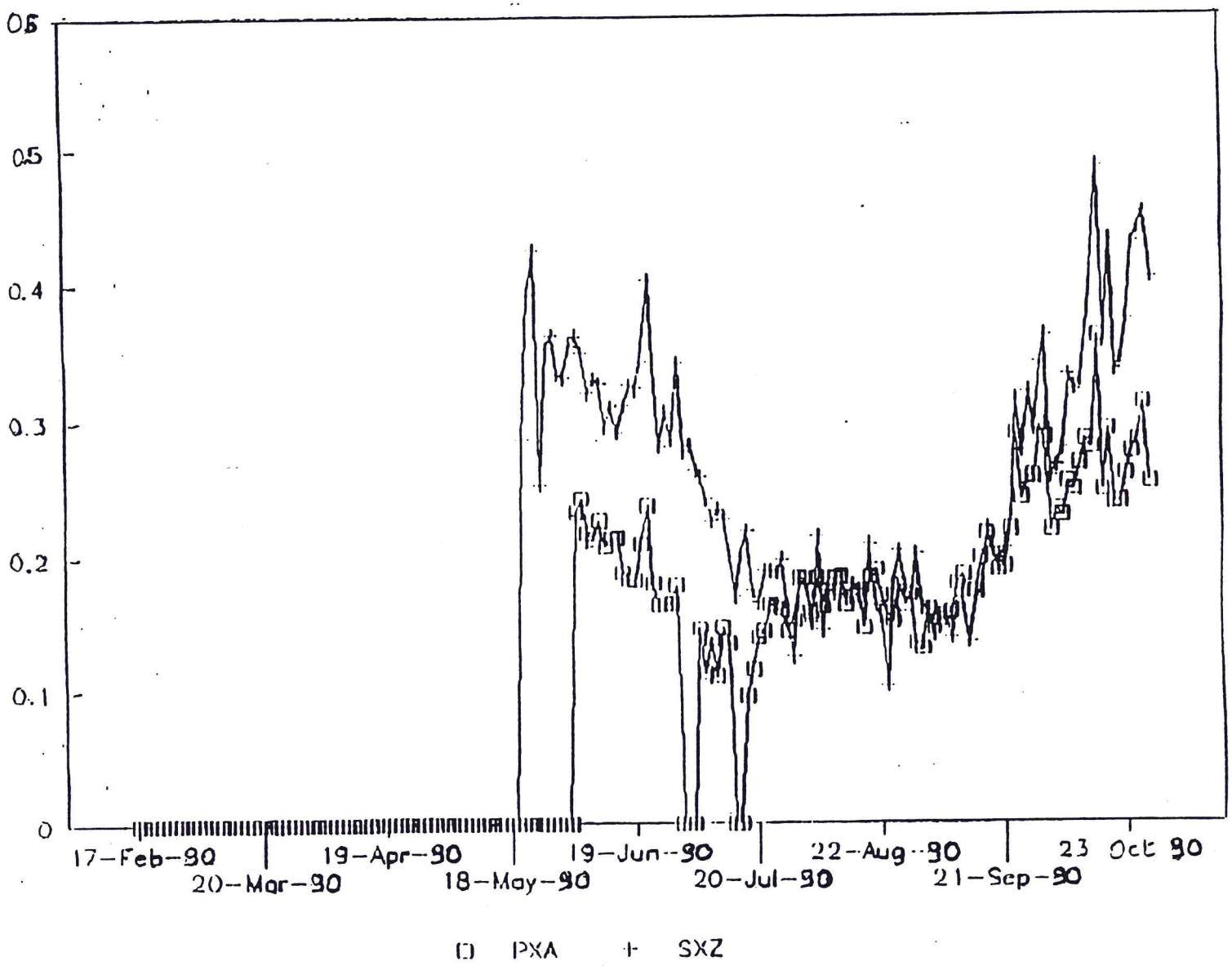
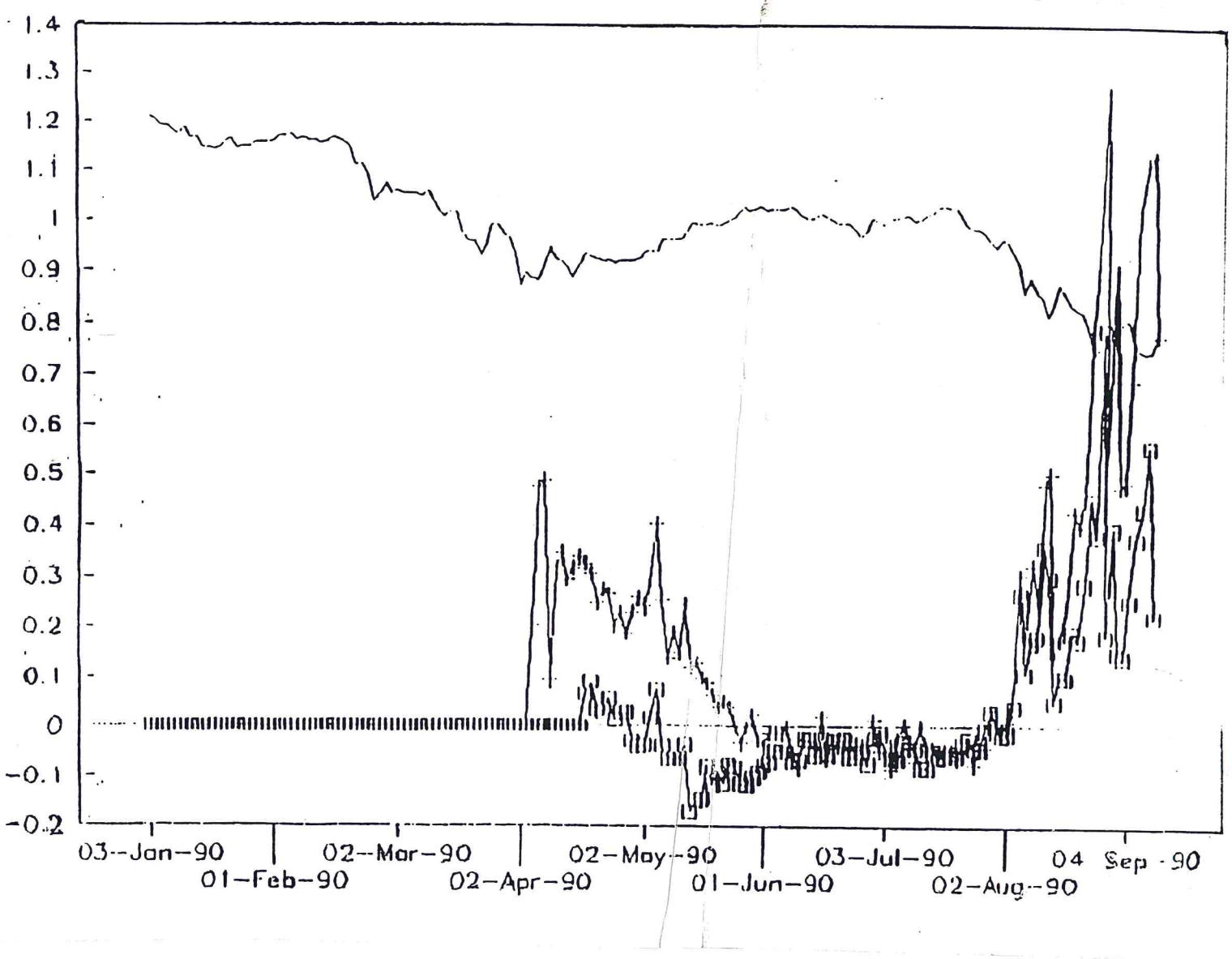


Figure 10
Relative Costs of the Paine Webber and Salomon NSA Call Warrants using 20% NSA Historical Volatility, April to October 1990



☐ PXA + SXZ _____ Normalised Nikkei

VI The Relationship between NSA Put Warrant Prices in North America and the Cash Market in Tokyo

During much of 1990 the Toronto and New York NSA put warrants were trading deep in the money. Frequently the puts traded for less than their intrinsic value, see Table 6. Tokyo's next trading session was the following day. Since much futures hedging was required to protect the issuers' positions, and that trading would lead to index arbitrage if the futures prices deviated much from fair value, the prices in North America provided a forecast of the likely prices in Tokyo. If the put was trading at a discount one would expect the Tokyo market to rise. Similarly, the forecast was for a fall in the Tokyo market if the put was trading at a premium. An indication of the size of the market is that during 1990 the NSA puts averaged 13% of the trading volume (and a similar fraction of the trading value) on the American Stock Exchange. Informal estimates by the authors of the size of the market in the US and Canada suggests that it was possible that upwards of 20% of the NSA futures trades in Osaka and Singapore were related to NSA put hedging. Consider for example, the SXA Salomon January 1993 NSA put. It had a strike price of 36,821.14, a currency conversion rate of 145.52 yen per US. dollar, and is worth 0.2 of an NSA unit. The intrinsic value of the put was

$$P = \frac{0.2\ (36{,}821.14\ -\ \text{NSA})}{145.52}\ .$$

Hence the implied NSA is 36,821.14 - 5 (145.52)P. Table 7 shows that on the twenty five trading days from August 1 to September 6, 1990, the forecast was correct all but two times including one tie.

There are many control aspects to a full study of this relationship such as open versus closed prices, futures effects, are futures and warrants giving the same estimate of cash prices, etc. However, there seems to have been a strong relationship between the price of the NSA put warrants in North America and cash prices in Tokyo on the next trading day.

Table 6
Percent of Days the Intrinsic Value Exceeded the Market Value

Month	DXA	SXA	SXO	PXB	EXW
Jan	0.0	0.0	na	na	na
Feb	0.0	0.0	0.0	na	na
Mar	18.2	22.7	27.3	na	na
Apr	65.0	70.0	85.0	0.0	0.0
May	40.9	40.9	40.9	0.0	0.0
June	0.0	0.0	0.0	0.0	0.0
July	0.0	0.0	0.0	0.0	0.0
Aug	43.5	43.5	43.5	0.0	0.0
Sep	57.9	52.6	52.6	5.3	0.0
Oct	52.2	47.8	52.2	4.3	4.3
Average	29.1	29.5	35.8	1.4	0.8
Exercise Price	37,517	36,821	37,472	29,249	28,425

Source: Clyman (1991)

Table 7
The Salomon Nikkei January 1993 Put Warrants Record at Predicting the Following Day's Change in the NSA in Tokyo

Date	SXA	Implied Nikkei	Nikkei Close	Prediction	
9/6/90	17.75	23,906	23,812	fall	√
9/5	17.00	24,442	24,078	fall	√
9/4	16.25	24,997	24,907	fall	√
8/31	15.625	25,452	25,978	rise	√
8/30	16.00	25,179	24,895	rise	X (even)
8/29	16.00	25,179	24,895	fall	√
8/28	15.50	25,543	25,710	rise	√
8/27	14.625	26,180	25,142	rise	√
8/24	16.625	24,725	24,166	rise	√
8/23	18.125	23,633	23,738	fall	√
8/22	16.00	25,179	25,211	fall	√
8/21	14.75	26,089	26,298	fall	√
8/20	13.50	26,998	26,490	rise	X
8/17	14.125	26,544	26,787	fall	√
8/16	13.875	26,726	27,549	fall	√
8/15	12.375	27,817	28,112	rise	√
8/14	12.875	27,453	26,673	rise	√
8/13	13.75	26,817	26,176	fall	√
8/10	12.875	27,453	27,329	fall	√
8/9	11.75	28,272	27,615	fall	√
8/8	11.125	28,726	28,509	rise	√
8/7	12.00	28,090	27,653	fall	√
8/6	12.625	27,635	28,600	fall	√
8/3	10.875	28,908	29,516	fall	√
8/2	10.50	29,181	30,245	fall	√
8/1	9.375	30,000	30,838		

Source: Modified from The *Wall Street Journal.*

VII Implications of the Findings and Concluding Remarks

The paper has described two favourable hedges involving Nikkei put warrants during the period November 1989 to February 1990. The cross border hedge involved shorting overpriced Canadian Nikkei put warrants which traded on the Toronto Stock Exchange and purchasing either Nikkei puts with negotiated terms over the counter in London or exchange traded puts on the American Stock Exchange. Since the Canadian puts were unavailable for three months from their issue in February and April 1989 they were not heavily advertised or known in the United States. US residents and citizens could have traded them at the time of the hedge, however. The reasons for the mispricing are

several. The puts were complex for most ordinary investors and all but experienced option traders in Canada likely evaluated them incorrectly. Evidence of this is found in the literature on them from various Canadian brokerage houses. Many investors in Canada and academics, see for example, French and Poterba (1991), were quite convinced that the Japanese market was overpriced. Even the Canadian investors bidding up of the price did not prevent them from making considerable profits later which the Nikkei fell sharply.[6] The Canadian puts finally declined into their theoretically correct pricing about a month after the US puts were trading on the American Stock Exchange.

The studies of Bernard and Thomas (1989, 1990), Affleck-Graves and Mendenhall (1992) and Aberbanell and Bernard (1992) show the slowness of individual stocks to react to new earnings information. Hence, it is not surprising that this convergence to efficiency of more complex cross border investments would take about a month to occur.

Interestingly, Bankers Trust also issued Canadian dollar against the US dollar put warrants in June 1990. These traded on the Toronto Stock Exchange at a time when many Canadians expected a sharp decline in the Canadian dollar while US exchange traded options on the Canadian dollar were actively traded. These puts were also overpriced and they stayed overpriced for the entire year until they and the US puts expired worthless in June 1991. This latter case has some parallels with the Nikkei put hedge but important differences.

With the Canadian dollar puts the difference in price could be explained by the fact that it was extremely difficult to short these puts.[7] For those that did including two of the authors there were considerable profits in a percentage but not absolute basis. In contrast it was not difficult to short the Canadian Nikkei puts in large numbers. Salomon Brothers and other issuers were in the position to participate in the mispricing hedge. Presumably for business reasons concerned with selling such products, they did not converge the mispricing to efficiency sooner than February 1990. The market did price the relative values of the Type II and Type III Canadian puts correctly. Other reasons for the temporary mispricing of the Canadian puts as discussed in the text are the risks of buy-ins, cross border risks, small relative currency risks and differing credit risks. The latter is mitigated somewhat in the hedge: sell Canadian Bankers Trust puts and buy US Bankers Trust puts. Still if an extraordinary event occurred and there was no trading in the Nikkei index the liquidity of the two types of puts could have been different.

The second hedge involved securities of fixed versus floating exchange rate on the American Stock Exchange. The explanation for this mispricing which also lasted about one month seems to be the price effect and the different ways one can view the currency risk and pricing. The price effect where the Bankers Trust US warrants had NSA sizes two and half times as large as the Kingdom of Denmark and the Salomon puts is totally analogous to the effect of low priced stocks in January studied by among others Blume and Stambaugh (1983). It is known that much of the January small firm effect can be equally viewed as a low price effect. Hence, it is not surprising that in the very

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6 According to Slocum (1993) investors in the four Bankers Trust warrants made a total profit of about $500 million.

7 Another example in Holland, with similar mispricings related to the inability to short the overpriced warrants, is discussed by Veld and Verboven (1992).

beginning of their trading the much higher nominally priced BT warrants traded for somewhat lower actual prices. Another possible reason for the discrepancy involves the currency risk. The theoretical models assume that currency prices are based on their forward rates. Hence, if investors were assuming that the lower yielding yen would not appreciate against the higher yielding US or Canadian dollars as evidence summarised by Froot and Thaler (1990) suggests for such currencies, then higher prices were warranted for the fixed exchange rate puts. Since even this explanation assuming that the forward rate equals the spot is not enough to explain the full extent of the mispricings it appears that a combination of the two effects and the premium that is warranted for eliminating the currency risk is the logical explanation.

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