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# Dual Listing of the SGX EURO STOXX 50<sup>®</sup> Index Futures in Singapore

Mr Tobias Hekster  
Managing Director, True Partner Education Ltd  
Senior Strategist, Algorithmic Training Group of Hong Kong

## Introduction

In December 2010, the EURO STOXX 50<sup>®</sup> Index future was listed on the Singapore Exchange. The key benefit of this project is the extension of trading hours of Europe's benchmark future product into the Asian time zone. The added listing allows investors to react to Asian market developments and trade the EURO STOXX 50<sup>®</sup> before the opening of the European markets. Furthermore, this additional listing enables local investors to trade futures on this European benchmark.

A well-known example of a successful dual listed future in Asia is the future on the Nikkei 225 Index, which has its primary listing on the Osaka Exchange, but also has a liquid listing on the Singapore Exchange. As these two types of Nikkei futures have an identical underlying (the Nikkei 225 Index), trading in an identical currency (the Japanese Yen) with identical expiration dates, the value of both listings must by default be identical.

In practice, the fact that the value ought to be identical in itself does not guarantee that both listings are not conflicting. This task of keeping both listings 'in line' actually rests with arbitrage traders between the products: as soon as the bid in Osaka would exceed the offer in Singapore, one could lock in an immediate arbitrage profit by selling in Osaka and buying in Singapore. Furthermore, a trader can quote in Singapore based on the markets in Osaka and vice versa.

The dual listing of the EURO STOXX 50<sup>®</sup> Index future, however, has one additional aspect: where the contract specifications were very similar in the Nikkei 225 Index (only the contract size differs), there is a material difference between the Eurex listing of the EURO STOXX 50<sup>®</sup> and the Singapore listing: the contract currency. Where the Eurex contract has a value of EUR 10 per index point, the Singapore contract has a value of USD 10 per index point.

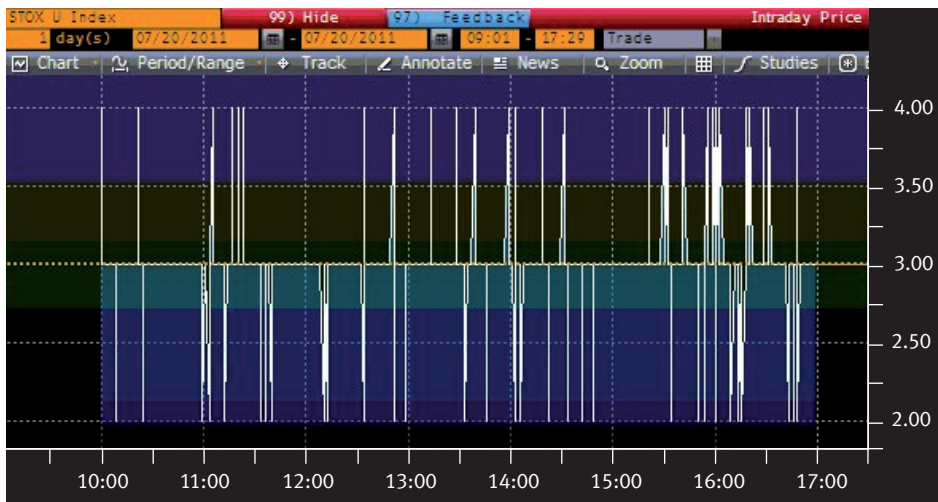
The fact that the Singapore contract is 'quantoed' from Euro to US Dollar adds some spice to what is still a fairly straightforward arbitrage between two futures on the same index. This article briefly describes what the current market looks like and based on these observations discuss the impact of currency fluctuations on this arbitrage. Also, included is how to potentially translate an opinion on the correlation between currency fluctuations and stock market movement into a position.

## Comparing Eurex and SGX

The afternoon trading session in Singapore, which starts at 13:30 Singapore time (which is 07:30 CET during daylight savings time) overlaps with the regular trading session on Eurex. Therefore, the afternoon session provides a clear insight into the opportunities for and activities by arbitrageurs. In the following two graphs, the difference is plotted between the bid price on Eurex and SGX (graph 1) as well as the difference between the offer price on SGX and Eurex (graph 2) on one day (July 20th).

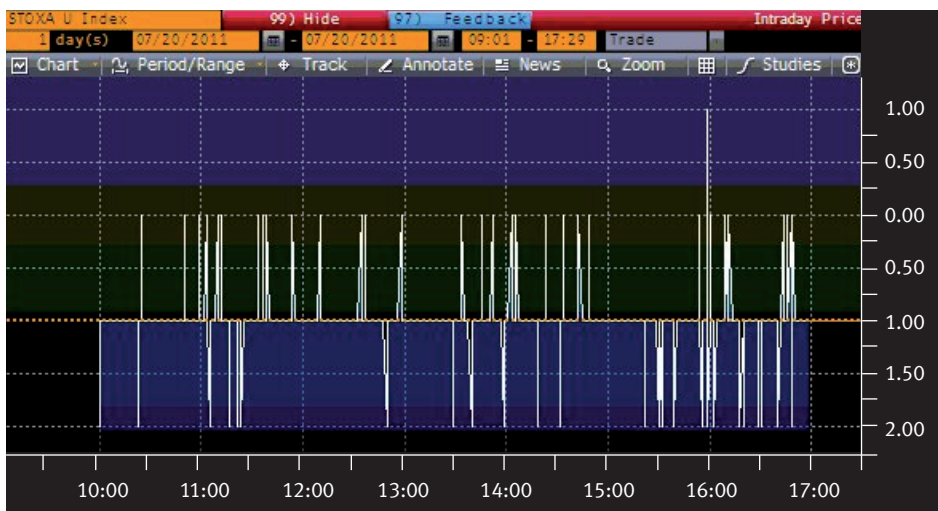
It is clear from these graphs that the vast majority of the time, the bid on SGX is three points below the bid on Eurex, whereas the offer on SGX is one point below the offer on Eurex. The consistency of these spreads do reflect a valuation difference: the quoter on SGX construes the mid-price of the USD-denominated contract to be one point below the mid price of the EUR denominated contract traded on Eurex.

**Graph 1: Bid on September future on Eurex – Bid on September future on SGX (times CET)**



Source: Bloomberg

**Graph 2: Ask on September future on SGX – Ask on September future on Eurex (times CET)**



Source: Bloomberg

## Drivers of the Valuation Difference

The reason for this difference is that a spread position between the two markets is not a fully static position. Assume we have the following position: (with a EUR/USD exchange rate of 1.40)

Position	Instrument	Price	Delta	Currency
Long 100	Future Eurex	2,200	1,000	EUR
Short 140	Future SGX	2,200	-/- 1,400	USD

As long as the EUR/USD exchange rate remains at 1.40, this indeed is a static position: for each point that the index rises, we will simultaneously earn EUR 1,000 from our Eurex position and lose USD 1,400 from our Singapore position. Obviously, the same applies for a drop in the index.

### Scenario 1

However, what would happen in the following scenario:

- EURO STOXX 50® Index rises 20 points
- Euro strengthens to USD 1.42

Position	Instrument	Result (local)	Result (USD)
Long 100	Future Eurex	EUR 20,000	USD 28,400
Short 140	Future SGX	-/- USD 28,000	-/- USD 28,000
Net Result			Profit USD 400

In this case, our position generates profit in the appreciating currency and generates a loss in the depreciating currency. Overall, we have a profit of USD 400 (which equates to roughly 0.28 points in the index). Furthermore, in order to fully hedge our position we need to sell 2 additional futures in Singapore (or alternatively, we could sell futures on Eurex, but there would be residual as the optimal number of futures to sell is 2/1.42).

### Scenario 2

But this effect is symmetrical, as the next scenario shows:

- EURO STOXX 50® Index drops 20 points
- Euro strengthens to USD 1.42

Position	Instrument	Result (local)	Result (USD)
Long 100	Future Eurex	-/- EUR 20,000	-/- USD 28,400
Short 140	Future SGX	USD 28,000	USD 28,000
Net Result			Loss USD 400

In this case, our position generates a loss in the appreciating currency and generates a profit in the depreciating currency. In this case, we lose 0.28 index points. In order to fully hedge our position, we need to sell 2 additional futures in Singapore.

Note that when the situation reverts to the start of the example (EUR/USD of 1.40 and no change in the EURO STOXX 50® Index) the profit (or loss) is actually locked in by the futures hedge:

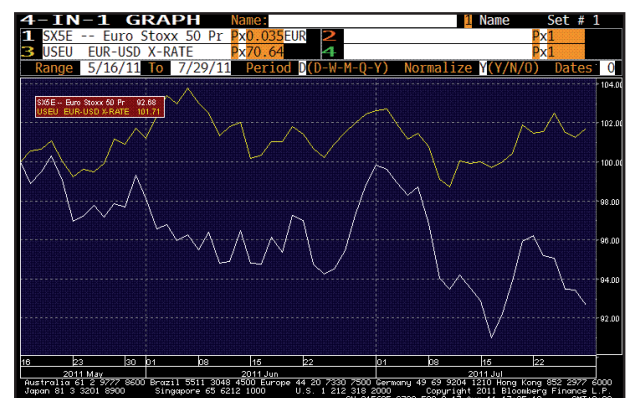
- In the first scenario, the USD 400 profit is lost again, but we can buy back the 2 futures 20 points lower, which also equals USD 400, and is a profit.
- In the second scenario, the USD 400 loss is recouped, but we need to buy back the 2 futures 20 points higher, which equals a loss of USD 400.

All in all, the situation somewhat resembles gamma-hedging of an options position: to maintain the correct amounts of futures in our spread position to remain hedged, we need to buy or sell futures when the exchange rate changes. The trouble, however, is that we do not know whether we are gamma long, benefitting from movement (as happened in example 1) or gamma short, suffering from movement (as happened in example 2). Or could we have an idea?

## Correlation between EUR/USD exchange rate and EURO STOXX 50® Index

The key consideration is the correlation between the EUR/USD exchange rate and the movement of the EURO STOXX 50® Index. And in the past months (actually since the Financial Crisis and especially since the US policy of Quantitative Easing) there has been ample evidence of this correlation: the so called 'risk-on, risk-off' trade.

- When the market becomes confident, investors dare to leave the safe havens (which tend to be USD-denominated) and opt for shares and anything but the USD. Thus the euro rises, as does the EURO STOXX 50® Index.
- But as soon as there is any sign of trouble people rush back into the safe havens, reversing the previous movements.



## Establishing a Theoretical Valuation (or estimation thereof)

If we do expect this pattern to hold, it is interesting to note two aspects of our example portfolio:

- The calculations are based on a per trading-day basis. As at 31 July, there are still 35 trading days left for the September futures.
- As described before, there is a similarity with options gamma: there is a profit (loss) that results from trading futures to maintain a hedged position following changes in the currency exchange rate. As with options gamma, these profits (and losses) increase with higher movements in the EURO STOXX 50<sup>®</sup> Index or the EUR/USD exchange rate (and especially with higher movements in both).

In order to show the magnitude of the correlation effect, we can run through a simplified example where a full (100%) correlation between the EURO STOXX 50<sup>®</sup> Index and the EUR/USD exchange rate is assumed. Except for this correlation, we apply the parameters as were present at 20 July.

Trading days to expiry	35
Implied volatility (EUR/USD) <sup>2</sup>	12 % (representing roughly 0.75% daily movement) <sup>1</sup>
Implied volatility (EURO STOXX 50 <sup>®</sup> ) <sup>2</sup>	20 % (representing roughly 1.25% daily movement)
Correlation factor	1
EUR/USD spot rate	1.45
EURO STOXX 50 <sup>®</sup> Index Futures	2900

- Using a correlation of 1, a typical day would show the following movements:
- EURO STOXX 50<sup>®</sup>: up (down) 36.25 points
- EUR/USD: up (down) 1.0875 cents
- A hedged position would consist of long 1 EUR future and short 1.45 USD futures

Therefore, applying the same calculation logic we used in the examples, each trading day will result in the following profit (using the position of 1 EUR denominated future as the base in our calculations):

Long EUR future	1.25% over 2900 = 36.25 points (in EUR)
Short USD future	-/- 36.25 x 1.45 = -/- 52.5625 points (in USD) At the new EUR/USD rate this corresponds to -/- 35.98 points (in EUR)
Profit	0.27 index points

Therefore, applying a correlation of 1 would result in a daily profit of 0.27 points per EUR-denominated future, for holding this spread position between the EURO STOXX 50<sup>®</sup> Index futures on Eurex and on SGX.

<sup>1</sup> The calculation of daily movement from annual volatility conveniently assumes 256 trading days per year. As the square root of 256 equals 16 the formula becomes: Daily volatility = Annual volatility / 16

<sup>2</sup> The implied volatilities can be retrieved from the options market and should be interpreted as the market's best estimate for the volatility with which these products will move over the time period between now and the expiry of these options.

## Simplified Formula for PnL

A rough (but intuitively nice) approximation would be the following: the PnL from the position is the difference in currency valuation (0.75%) over the value change of the future (1.25% of 2900).

$$\text{PnL (daily)} = [\text{Volatility EUR/USD}] / 16 * [\text{Volatility Stoxx 50}] / 16 * \text{Price Stoxx 50 Future}$$

This expected profit from holding such spread position should be reflected in the prices between the two future contracts: the EUR-denominated contract should trade at a premium to the USD-denominated contract. Using the parameters from this example, the premium should be 0.27 points over 35 days equals 9.45 points.

But one critical input to this calculation is the correlation of 1; in reality all different combinations of EUR/USD movements and movements in the EURO STOXX 50<sup>®</sup> are possible, including days with negative correlation. And at a perfectly negative correlation, obviously the outcomes are opposite. Over a longer period, a modification to the proxy formula above can be applied:

$$\text{PnL} = [\text{Volatility EUR/USD}] / 16 * [\text{Volatility EURO STOXX 50}^{\text{®}}] / 16 * \text{Price Stoxx 50 Future} * \text{Correlation} * \text{number of days}$$

When we observe the valuation difference at which the USD-denominated EURO STOXX 50<sup>®</sup> Index future was quoted on 20 July on the SGX versus the Euro-denominated contract on Eurex, we can calculate the implied correlation, based on our previous assumptions:

- Current Futures Price in EURO STOXX 50<sup>®</sup> at 2,900
- Annualised volatility of 12% in EUR/USD exchange rate (thus 0.75% daily)
- Annualised volatility of 20% in EURO STOXX 50<sup>®</sup> (thus 1.25% daily)
- 35 trading days left

The EUR-denominated futures quotes 1 point over

$$\text{Premium} = \text{Daily Move [EUR/USD]} \times \text{Daily Move [Stoxx]} \times \text{Current Future} \times \text{Correlation} \times \text{Trading Days}$$

$$1 = [12\% / 16] \times [20\% / 16] \times 2,900 \times 35 \times \text{Correlation}$$

Therefore, the expected correlation is roughly 0.11.

Please note that this correlation serves more as an indication of the expected relationship between the EURO STOXX 50<sup>®</sup> Index and the EUR/USD exchange rate: given the implied volatility of the EURO STOXX 50<sup>®</sup> Index and the EUR/USD exchange rate, the implied correlation is retrieved from the actual premium (or discount) for the EUR denominated future.

As not only the directions of the stock movements, but also the magnitude of the movements define the premium (or discount) one would be prepared to pay for the EUR denominated future, one cannot simply compare this implied correlation with observed historical correlation.

But patterns and movements in the implied correlation are certainly interesting, as they indicate market expectations of the relationship between stock indices and currencies. And any market participant could trade against these market expectations if his or her opinion differs.

These estimations are as strong as the assumptions used for input and it is clear a lot can change over the next 35 days. And as with option gamma in general, the magnitude of this effects increases significantly with the magnitude of the movements involved.

This magnitude can be expressed by the situation two weeks later, in the first week of August:

- The USD-denominated future trades 3 points below the EUR-denominated future
- The EURO STOXX 50<sup>®</sup> Index has dropped to 2,500 points
- The volatility of the EURO STOXX 50<sup>®</sup> Index has risen to 32%
- The volatility of the EUR/USD exchange rate has risen to 16%

In a correlation 1 scenario, the daily profit from the spread position would be 0.52 points. With the number of trading days until expiration now at 25, the premium for the Euro denominated future would equal 13 points with a correlation of 1. The actual premium of 3 points thus reflects an implied correlation of 0.23.

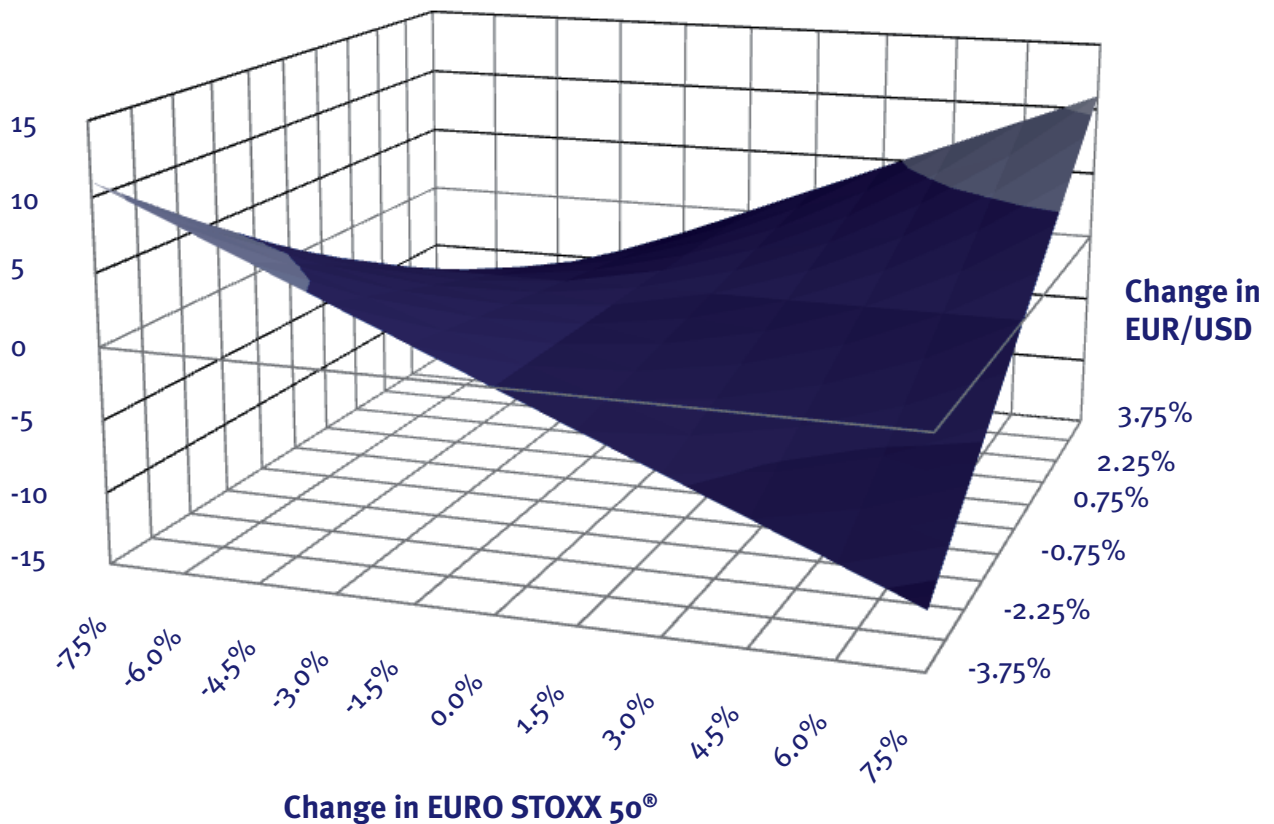
And during the recent burst of volatility, some individual days have resulted in significant moves of both the EUR/USD exchange rate and the EURO STOXX 50<sup>®</sup> Index, resulting in daily results exceeding one index point.

Such scenarios are reflected in the graph below, which shows the effect in index points of different combinations for the EUR/USD exchange rate and the EURO STOXX 50<sup>®</sup> Index, on a daily basis. As is visible, a severe move in both global indices as currencies can result in a daily spread-result of several points per future.

When observing these possible outcomes, we have to revert to the questions asked before:

- Do we expect significant volatility in the near future?
- Do we expect a pattern in the movements of the EUR/USD exchange rate and the EURO STOXX 50<sup>®</sup> Index, thus a significant positive (or negative) correlation?

If the answer to both questions is a resounding yes, one should be interested to trade the spread between the EURO STOXX 50<sup>®</sup> Index futures on Eurex and those on SGX.



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**Singapore Exchange** • London • Tokyo • Beijing  
2 Shenton Way, #19-00 SGX Centre 1, Singapore 068804  
Main: (65) 6236 8888 Fax: (65) 6535 6994