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**Listed dividend swaps on Eurex:
Does mispricing mean arbitrage opportunities?**

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Abstract

With the development of dividend-based strategies, dividends emerged as a genuine asset-class over the last ten years. Mainly OTC, the market for dividend derivatives proved to be imbalanced between supply and demand, creating mispricing. Some products, however, tend to become standardized: Dividend swaps on the EURO STOXX 50 Index were launched on Eurex in June 2008. Our paper aims at testing whether these dividend swaps are fairly priced. We find that there is mispricing regarding these products and we try to quantify potential arbitrage opportunities. Unfortunately for arbitrageurs, the products' low liquidity (epitomised by large bid-ask spreads) reduce significantly their number.

HEC Group

May 11, 2009

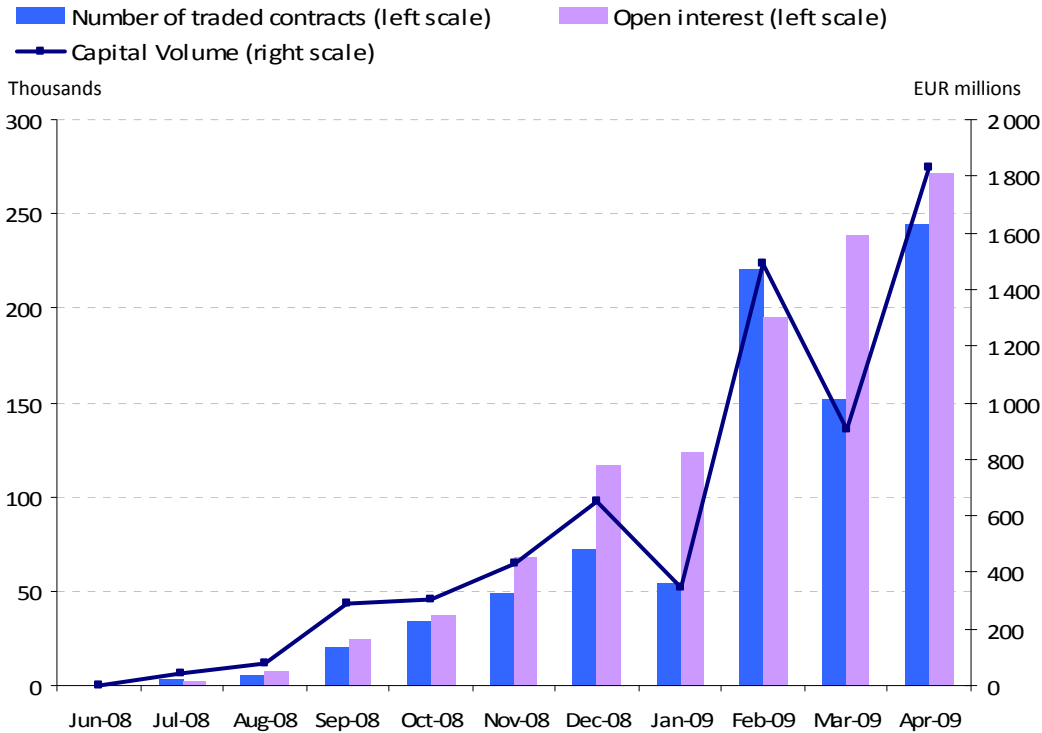
CONTENT

INTRODUCTION	3
1. MARKET AND PRODUCT PRESENTATIONS	7
1.1. The market for dividend derivatives	7
1.2. The market for dividend swaps	8
1.2.1. Characteristics of a dividend swap	8
1.2.2. Supply and demand: The cause of mispricing	10
1.2.3. Benefits and drawbacks of this market and this product	11
2. EMPIRICAL STUDY	14
2.1. Description of the sample	14
2.2. Methodology and analysis	16
2.2.1. Mispricing detection	16
2.2.2. Addressing main pitfalls	25
CONCLUSION	33
ACKNOWLEDGMENT	35
REFERENCES	36
APPENDIX: Additional graphs which show our results	37

INTRODUCTION

Dividends are increasingly used investment tools, insomuch as they tend to become a genuine asset-class with a variety of products (such as futures or options) mainly traded on the OTC market. Dividend derivatives are becoming very popular products. They have been listed in Europe for the first time in June 2008, on Eurex, a leading exchange platform jointly operated by Deutsche Börse and SIX Swiss Exchange. The newly listed products, dividend futures on the EURO STOXX 50 Index, seem to be a success and the market is growing as shown in **Figure 1** below. On April 22, 2009 Deutsche Börse announced that Eurex will list products with even longer maturities as of beginning of May and that they will be granted the same trading time frame than other derivatives.¹

Figure 1. Dividend swaps' market on Eurex



Source data: Eurex

¹ Deutsche Börse's website, April 22, 2009
 "Eurex to enhance successful Index dividend future contract".

Such an event is quite surprising as it occurs during an unprecedented financial crisis. One indeed is most likely to expect asset-classes to disappear, not to be created. However, there is still some room for such products in the market. It is all the more surprising so as it is an asset-class born on pure uncertainty. In fact, all products are more or less directly linked to an economic factor whereas dividends are direct functions of companies distribution policies. To be more precise, following the dichotomy suggested by a Research Paper of Goldman Sachs (released in September 2006), the distribution policy is only accounting for half the truth as it constitutes the “*propensity to pay dividends*” of a firm. There is also another factor: The firm’s “*capacity to pay dividends*”, which is determined by its capacity to generate profit. Thus, the payoff of such a product is made up of two uncertainties; one relying on the ability of the company to increase its earnings and the other on its will to distribute some. In a former article, Black (1976) argued that “*the harder we look at the dividend picture, the more it seems like a puzzle, with pieces that just don’t fit together.*” Following his idea, it is practically impossible to know why companies do pay dividends and why investors do pay attention to dividends. As a matter of fact he showed that companies have equal (or even more) reasons not to pay dividends. Thus, why such a success for these newly listed products? We will show how the market has emerged and describe its characteristics. Assuming that supply and demand exist, the answer can be provided as follows: Listed products, at least on Eurex, are on indexes and not single-stocks.² This reduces dramatically the uncertainty relative to whether the firm will pay dividends or not as the index (the EURO STOXX 50 Index in our case) can be considered as a basket of single-stocks. Thus, it can be rational to assume that at least one of the constituent companies of the index will pay dividends. So the payoff of an index dividend swap exists and has a very low probability to be equal to zero. The study of Fama and French (2001) seems to grant us credit on this assertion. They were indeed able to determine the characteristics of dividend payers that we summarized in **Table 1** in the next page.

² This idea is developed further away in our study.

Table 1. Dividend payers' characteristics

	Former payers	Firms that have never paid dividends	Dividend payers
Profitability	Low earnings (distressed)	Low earnings but profitable	Relatively high earnings
Investment	Few investments	Strong investments (exceed earnings)	Less than earnings
Size	Small or large	Small	Large

Source data: Fama and French (2000)

According to their study, large profitable firms are the most likely to pay dividends. As the EURO STOXX 50 Index is constituted by the 50 largest European firms in terms of market capitalization, we can think not only that the payoff exists and is not equal to zero, but also that it can be potentially substantial, as these companies are able to attract investors, potentially with increases in dividends. However, Fama and French qualify that conclusion: They showed that the number of firms paying dividends decreased drastically during the 1926-1999 period mainly because of an increase in publicly traded firms having the *"characteristics of firms that have never paid"*; but also because there is a general lower propensity of firms to pay dividends. The latter reward shareholders by other means such as share repurchases for example.³ Thus, the payoff exists but it is nevertheless uncertain; quite an unattractive feature for an investor in today's markets *a priori*. So where does this infatuation for such products stems from? Are these newly atypical listed products fairly priced? We address these issues in two sections. The first is dedicated to the markets of dividend derivatives and dividend swaps; the second is an empirical study which aims at checking whether there is mispricing, and should the case arise, if arbitrage opportunities can be exploited by investors. If the financial literature is rich with articles about the market for such products, it seems relatively poor to the best of our knowledge as for their pricing (because the market is very young as we will see). However, a study about pricing violations and arbitrage opportunities on dividend swaps listed on Eurex was conducted by Wilkens and Wimschulte (2009) a few months ago. The aim of our thesis is thereby to go further by undertaking our own empirical study so as to draw our own conclusions and compare it to theirs. For sake of clarity, we stress the importance of the nuance that exists for us between mispricing and arbitrage in this case. We will show that mispricing exists but it may not

³ This idea is not only developed by Fama and French (2000), but also by Black (1976).

necessarily be synonym of arbitrage. If by replication we find price discrepancies, they seem not viable because of the intrinsic characteristics of the products, especially their low liquidity (large bid-ask spreads).

1. MARKET AND PRODUCT PRESENTATIONS

1.1. The market for dividend derivatives

Eleven years ago, Brennan (1998) foresaw the creation of a market for dividend strips, necessary for various reasons. First, he argued that such a market (and by extent a market for dividend derivatives) would provide valuable information about what he called the “*current fundamentals of the market*”, namely dividends. Indeed, equity markets should clearly reflect the growth rate of dividends, which is an important input in stock prices, that are in fact considered as perpetuities on dividends.⁴ But according to Brennan, equity markets are opaque on this topic, leading to market levels completely disconnected from rational expectations: Investors not being able to extract the information can only rely on their “*hopes on future resale values*” and they “*cannot pit their estimates against those of the market*”. Hence the necessity to find a way to shed light on these market implicit fundamentals. At that time, Brennan was convinced that such markets would eventually emerge. In the light of his argumentation we understand that creating a market for dividend derivatives responds to a financial necessity. But how did this market appear in practice? To answer this interrogation we will rely on the comprehensive article of Manley and Mueller-Glissmann (2008). Before going ahead, it is interesting to observe that they seem to agree with Brennan’s argument. They indeed acknowledge that estimating dividends “*can be crucial for competitive pricing*”, especially for products with long maturities which bear more risks if dividends are not estimated correctly “*because the cumulative dividends paid until maturity have to be estimated*”. Thus, the importance of dividends is crucial. That is why such a market is needed.

According to Manley and Mueller-Glissmann the market actually emerged around 1999, even though products on dividends were marginally exchanged before, under the form of over-the-counter transactions. It developed with “*an excess supply in the derivatives market*”: Banks increasingly issuing structured products for retail and institutional investors

⁴ This is the Gordon-Shapiro formula (1956) which is also explained by Brennan (1998): “*the rational [stock] price is equal to the current dividend divided by the difference between the expected rate of return and the expected dividend growth rate*”.

tend to bear dividend risks that they want to get out of their books as much as possible. To put it in concrete terms, banks are “*short calls from selling structures with asymmetrical upside exposure such as capital-guaranteed products and long puts from selling reverse convertibles*”.⁵ Reading between the lines, we understand that capital-guaranteed products incorporate call options that banks sell. Thus, to hedge their market risk and have a delta-neutral position banks have to be long the underlying. As the underlying is in general an equity component (index or stock), the bank becomes long dividend. The same reasoning goes for the long put position: If banks buy puts, they must also be long the underlying to delta-hedge their positions. So in both cases banks are long the underlying, and consequently long dividends. Therefore the primary need for such a market is hedging (for banks). In order to minimize this dividend risk, they have to seek counterparties which are willing to get an exposure to the dividends paid by the underlying. So the market appears to be purely institutional, the parties being mainly, at least at the beginning, banks and derivatives dealers. This accounts for the cradle of the dividend derivatives in the light of Manley and Mueller-Glissmann. So among all the derivatives on dividends that we can think of, why is it the dividend swap that focuses investors’ attention? We deal with this topic in the next subsection but first we need to present the characteristics of such a product.

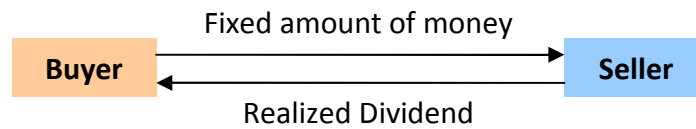
1.2. The market for dividend swaps

1.2.1. Characteristics of a dividend swap

A dividend swap may be defined as a financial derivative product which gives to its buyer an exposure to market realized dividends in exchange of a fixed amount. The transaction is illustrated in **Figure 2** in the next page.

⁵ Manley and Mueller-Glissmann explain that a reverse convertible is “*a bond that can be converted into the underlying asset at the discretion of the issuer at the set date if the price of the underlying is below a preset strike level. In return the investor gets a higher yield than on a straight bond*”.

Figure 2. A dividend swap transaction



Source: Goldman Sachs research paper (2006)

It actually works like forwards or futures (if it is standardized) because there is no cash flow at the initiation of the transaction and payments are theoretically made at maturity (the third Friday of December in Europe, December 31 in the United States according to Eurex and Goldman Sachs) even though in certain cases they can be unwound before. Its underlying is the dividend provided by individual stocks or indexes.⁶ Dividend swaps based on single-stock dividends are exclusively traded in over-the-counter markets and are company-focused so they do not offer the same exposure to investors as index dividend swaps. Because our interest in this paper is to study the possible mispricing of listed index dividend swaps on Eurex we will only develop the characteristics of the latter.

So how does an index dividend swap work in practice? In **Figure 2** are shown the exchanged cash flows (or the legs) of the swap. The buyer commits to pay the fixed amount which is the market-implied level of dividend (given by the level of the dividend swap) expressed in index points times the amount of money she is willing to invest; and the seller commits to pay the realized dividend level at maturity multiplied by the same amount.

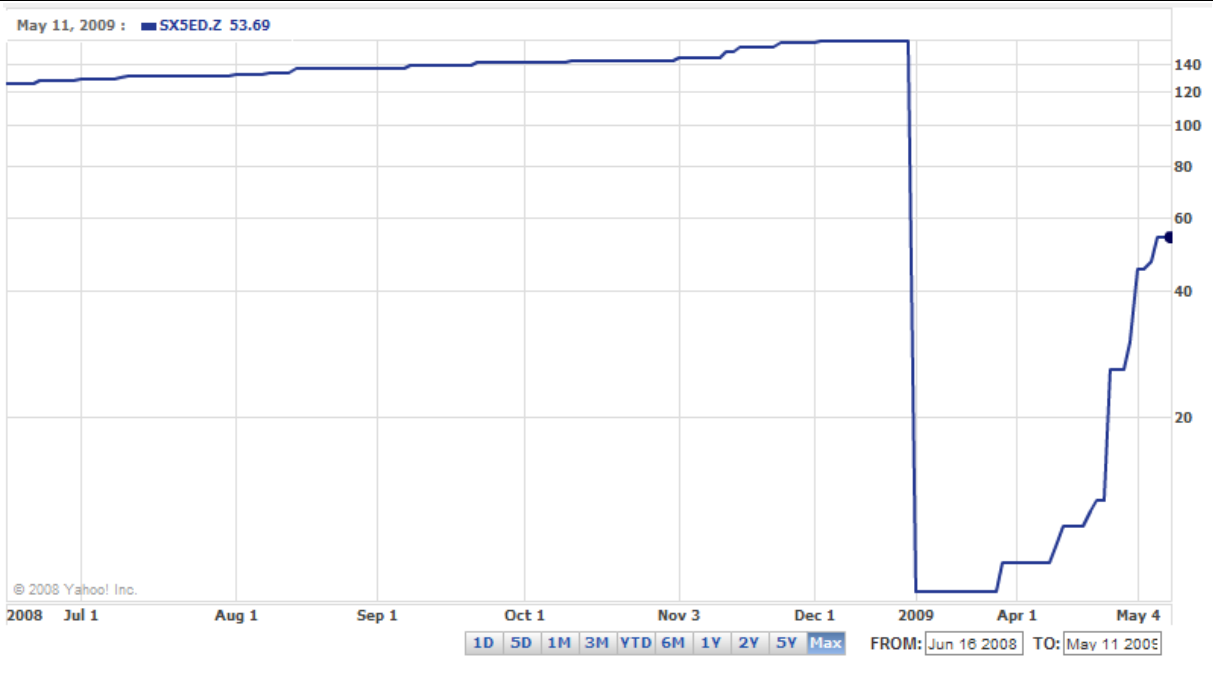
How is the underlying determined for index dividend swaps? The underlying is the cumulative dividend (paid by the constituent companies of the index) expressed in index points. That being said, to speak in concrete terms we will use information from Stoxx Ltd. (2008) in order to understand how the underlying is calculated for the products we are studying. Their underlying is the Dow Jones EURO STOXX 50 Dividend Points (DVP) which is computed continuously as the weighted-average of the gross dividend per share times the shares available for trade (the free float) of the constituents of the index, adjusted by the euro exchange rate for the local currency (when applicable) and divided by the divisor of the Dow Jones EURO STOXX 50 Price Index.⁷ So this product enables the buyer to be exposed to

⁶ When dealing with indexes professionals talk about “cumulative dividends” because the considered dividend is the sum of dividends paid the companies which constitute the index.

⁷ The weights are the same as those of the constituents in the index itself.

the cumulative gross dividends of the index. Let us introduce an example. **Figure 3** below, shows the level of the Dow Jones EURO STOXX 50 Dividend Points. It is currently (May 11, 2009) at a level of 53.69 index points.

Figure 3. Level of the Dow Jones EuroSTOXX50 Dividend Points from creation onwards



Source: Yahoo! Finance

Suppose an investor wishes to be exposed to the 2009 dividend on the EURO STOXX 50 Index. She purchases a dividend swap maturing in December 2009. The settlement price (which will be defined in section 2 of our study) on May 11 was 110.80 index points (compared to the 53.69 index points of the underlying). Now suppose this investor wants to bet an amount of EUR A for each dividend point. He will have to pay EUR 110.80 x A in order to receive at maturity a euro-amount equal to the dividend paid on the index (in index points) times A (and vice-versa for the seller).

1.2.2. Supply and demand: The cause of mispricing

Now that we saw how dividend swaps work, we are going to present the market for these products under Manley’s and Mueller-Glissmann’s magnifying glass.

Banks, as we have seen, are the source of dividend supply because of their positions in the derivatives market, which lead them to bear dividend risks that they are eager to

minimize. It seems that *“many of them prefer to fully or partially offload dividend risk via dividend swaps”*. Hence the importance of these products.

The demand side is more scalable through time. As we underlined previously, the main counterparties of banks when the market for dividend derivatives emerged (around year 2000) were derivatives dealers. But this demand was far from being enough to match the supply level. Indeed, supply levels were very high, especially for index dividend swaps, and the derivatives dealers seemed not to be willing to have such an exposure to realized dividends. Thus, as in any other market in which supply exceeds demand, prices were pulled down and the products were traded at a discount: *“Following an increasing supply of dividends, especially for indices, and limited demand, market-implied levels of OTC trades were at deep discounts relative to subsequently realized levels and often implied negative or no future dividend growth”*. As Manley and Mueller-Glissmann then underline, the discounts accounted for the increasing number of transactions. Institutional investors, and more specifically hedge funds, have made up the most of demand since 2004: *“Dividend swaps were a major profit contributor to multi-strategy and macro hedge funds in 2005 and 2007”*.

Since its creation the market has evolved and its evolution is expected to accelerate in the future years. However, if price discounts tend to mitigate, mispricing is persistent as we will show in the second section of our study. Moreover, the main sales' argument for selling such products is the deep discount that buyers could benefit.⁸ In difficult times, they are still mostly traded at a discount.

1.2.3. Benefits and drawbacks of this market and this product

“There is considerably less risk associated with the dividends on the S&P 500 in any given year than associated with the market itself”. This assertion of Brennan (1998) suggests that the S&P 500 is more volatile than its dividends. So if we extend his observation to any other equity index, then as a rule of thumb, dividend markets tend to be less volatile than equity markets. Basing his argument on what he calls the *“simple Gordon model”*, presented earlier as the Gordon-Shapiro formula, he pointed out that dividends were the main component of equity markets. But they are not exclusive, there are many other factors influencing equity markets indirectly (one may think of oil prices for example). Thus, additional factors add uncertainty, therefore volatility. So obviously the benefit of such a

⁸ According to Mr. Jean-Paul Corda, Salesperson at Goldman Sachs (April 10, 2009).

market for dividend swaps is, as borne out by Manley and Mueller-Glissmann, that *“the dividend market provides investment opportunities with attractive risk-return trade-offs for fundamental investors”*. This property is also acknowledged in the brochure release by Eurex in 2008.

Dividend swaps also offer other properties such as *“low correlation to traditional asset classes of bonds and equities”* and *“rise with inflation”* (Eurex, 2008). Indeed, Eurex *“carried a study out of the relationship between (daily) changes in the Dow Jones EURO STOXX 50 Index December 2008 dividend swap and the (daily) change in three-month EURIBOR, in Dow Jones EURO STOXX 50 Index and in generic ten-year European government bond yield for the period from March 16, 2006 to March 14, 2008”*. Thus Eurex decided to measure the correlation between the December 2008 dividend swap and three other market factors. The results of this study, based on regressions, show very low correlations between these factors with R2 statistics close to 1% for any of the three regressions.⁹ Thus, the dividend market is less volatile than the equity market, and less correlated to traditional asset classes. As for inflation, it appears that dividend swaps are a good way of hedging it. Manley and Mueller-Glissmann indeed emphasize that dividends are function of the companies’ nominal earnings and not real earnings. As the latter are not adjusted for inflation, the investor is fully exposed to *“economic performance”*.

Moreover, and more importantly, Brennan (1998) saw two major ways that a potential market in dividend strips (and by extension a market in dividend swaps) *“could enhance the efficiency in the economy”*. First, it would allow investors to invest in a market more closely related to the expectations on the economy, namely dividends (what he calls the *“current fundamentals in the economy”*); and second, it would increase *“the informational efficiency of the market”*. As we discussed in the beginning of this section, such markets could transmit information such as implied dividend growth so as to improve the pricing in equity markets. Manley and Mueller-Glissmann also argue that such a market would provide information of credit markets. Indeed, following the idea of Black (1976), dividends can be seen as a return to shareholders but also as a potential loss for creditors. He said that there was no easiest way for a company to prejudice its creditors than *“to pay out all of its assets in the form of a dividend, and leave the creditors holding an empty shell”*. Thus dividends are right in the middle of the everlasting conflict of interest between a

⁹ For more information please refer to the brochure released by Eurex in 2008 (listed in our references).

company's shareholders and creditors. Conversely, a company cutting its dividends might signal that it is distressed, owing to its debt burden. As Manley and Mueller-Glissmann put it: *"Because increases in dividends might be a disadvantage for a company's creditors whereas cuts might help them, dividend growth may change a company's credit risk"*.

However, if these benefits appear to be substantial, they argue that *"trading dividends through dividend swaps does present some problems"*. They indeed identify three major problems, as a mirror of the three benefits listed previously.

First, the market for dividend swap (as we have seen) exists in its actual form from an imbalance between supply and demand. Market implied dividends (measured by dividend swaps) may therefore differ substantially from realized dividends if demand's risk-aversion increases. This situation may lead to an increase in volatility and mitigate the benefits of lower risk that the market for dividend swaps theoretically offers.

Second, with this potential rise in volatility, the correlation between dividend swaps and other asset-classes may increase significantly and reduce the potential diversification benefit that an investor would currently (theoretically) enjoy.

Third, the market for dividend swaps is very young and do not offer sufficient depth and liquidity for information to be conveyed properly. We will show in the next section that the market seems to price products with large bid-ask spreads.

Thus, the market for dividend is young but growing. When it comes to pricing, is a transparent market efficient? We will now try to answer this question by undertaking an empirical study based on data provided by Eurex.

2. EMPIRICAL STUDY

As mispricing opportunities tend to be more frequent with new derivatives, we studied whether the newly listed dividend swaps on Eurex are fairly priced. Wilkens and Wimschulte (2009) provided a first empirical study about the pricing of dividend futures in the European market and pointed out that there existed substantial pricing imbalances. According to them, violation of the put-call parity for dividend paying stocks “cannot be fully explained by transaction costs and other potential trading constraints”. Following this paper, arbitrageurs should have made this situation disappear, unless some other elements prevent them from making a profit.

The main goal of our study is to quantify the amplitude of the mispricing and to assess to what extent traders can take advantage of the situation. We also focus on different replication strategies in order to check whether some of the latter constantly allow arbitrageurs to make a profit. Finally, when a situation of mispricing is detected, we try to provide explanations for it.

2.1. Description of the sample

Our study mainly focuses on the pricing of the Dow Jones EURO STOXX 50 Index Dividend Futures, listed on Eurex since June 2008. As suggested by the brochure released by Eurex in 2008, our approach is to check whether the implied index dividend swap given by the put-call parity relationship for dividend paying stocks (adapted to an index) provides a result consistent with the effective product’s market price.¹⁰ In other words, our starting point is to check whether the put-call parity relationship is violated or not.¹¹ So, adapting it for an index (in our case the EURO STOXX 50 Index) and solving it for the 2009 implied dividend price at time t leads to the following equality (ESX 50 standing for EURO STOXX 50):

$$PV(\text{Div}_{\text{Dec09}})_t = \text{ESX 50 level}_t + \text{Put}_{\text{Dec09}}(\text{ESX 50})_t - \text{Call}_{\text{Dec09}}(\text{ESX 50})_t - PV(K)_t$$

¹⁰ In this brochure, Eurex highlights the fact that the put-call parity relationship delivers a quite accurate result as for the product’s price verification.

¹¹ The put-call parity at time t for dividend paying stocks (using puts and calls with the same strike price K) is given by: $S_t - PV(\text{Div})_t + P_t = C_t + PV(K)_t$, where S_t is the stock price at time t , $PV(\text{Div})_t$ is the present value of dividend payment at time t , P_t is the put price at time t , C_t the call price at time t and $PV(K)_t$ the present value of the strike price at time t .

Before we give further details on our study please note that:

- The dividend swaps listed on Eurex all mature in December each year, which explains why we focused on the December implied dividend in the previous formula. Obviously, for the relationship to hold we must consider options on the index also maturing in December each year.
- Dividend flows are cumulative each year so we must be cautious about the previous formula. It needs further adaptation when considering maturities farther than December 2009. For example, if we wanted to compute the implied level of dividends for 2010 using the previous formula, we would have the following relationship:

$$PV(\text{Div}_{\text{Dec09}})_t + PV(\text{Div}_{\text{Dec10}})_t = \text{ESX 50 level}_t + \text{Put}_{\text{Dec10}}(\text{ESX 50})_t - \text{Call}_{\text{Dec10}}(\text{ESX 50})_t - PV(K)_t$$

According to Eurex, the **price of the Dow Jones EURO STOXX 50 Index Dividend Swap** should be given by the following relationship: $PV(\text{Div}) \times (1+r)^T$ (where r is the risk-free rate and T the number of days to December divided by 360), as the maturities of the contract are in December of each year.

Bearing these calculation details in mind, we built our sample from February 27 to March 31, 2009, gathering daily data on:

- Dividend swaps for all available maturities at that time (Dec-09, Dec-10, Dec-11, Dec-12, Dec-13, Dec-14 and Dec-15)¹²
- Options on the EURO STOXX 50 Index (puts and calls) matching the dividend swaps maturities for all available strikes
- The levels of the EURO STOXX 50 Index (each day's closing level)

In a first approach we used settlement prices for the financial products we considered. In particular, we used daily settlement prices for the dividend swaps, which are derived for the current maturity year from *"the volume-weighted average of the prices of all transactions during the minute before 17:30 CET, provided that more than five trades transacted within this period"* (according to the Eurex brochure). We are aware that for

¹² Eurex has listed 3 longer maturities since then (Dec-16, Dec-17 and Dec-18).

these products such an approximation may lead to results that do not reflect real market situations. However, as a first approach, we think this approximation may be acceptable as the settlement prices result from real transaction prices. As for options, Eurex states that *“the Daily Settlement Prices for equity index options (as well as Weekly Options) are determined through the Black/Scholes 76 model. If necessary, dividend expectations, current interest rates or other payments are taken into consideration.”* Here again, as a first approach, we used settlement prices for options in our study. In the second part of this section, we will try to reflect real market conditions by correcting these approximations: We add bid–ask spreads to these settlement prices for dividend swaps and options.

As for the interest rate, we used Libor 9m for December 2009 dividend swaps and, for longer maturities, the appropriate rate on the euro area central government bonds yield curve, i.e. the rate matching dividend swaps’ different maturities.¹³ Again, we are aware that in reality, investors have to add some spread to the risk-free rate. In the second part of our study, we will also try to compute the optimal funding spread that would allow investors to make a profit on average.

2.2. Methodology and analysis

2.2.1. Mispricing detection

Using our previous sample of data, we calculated the theoretical price of dividend swaps on the EURO STOXX 50 Index for all maturities, with all available options. We then computed the difference between the implicit level of dividend that is priced by the market (given by the replicating portfolio made up of the corresponding options as detailed previously) and the price of the dividend swap for a given maturity.

One of the main difficulties of our study was the treatment of intermediary flows of dividends. We consider two ways to address this issue. First, in order to be exposed to the dividend flow of, let’s say, 2010, one can consider that it is possible to hedge the 2009 dividend flow by a 2009 dividend swap. For example, by replicating a long position on the 2010 dividend flow with options maturing in 2010 (using the put-call parity) and by taking a

¹³ Source: British Bankers Association: www.bba.org.uk

short position on December 2009 dividend swaps, we are able to assess whether the December 2010 dividend swap is mispriced or not. However, if mispricing is detected, a part of it can be due to a mispricing in December 2009 dividend swaps.

The second way would be to take a cumulative exposure on the dividend flows from today to maturity by replicating the dividend flows to maturity with options (using again the put-call parity for dividend paying stocks) and taking the opposite position on all available dividend swaps. For example, one can replicate the dividend flows until 2010 with options and, in order to make a profit, take the opposite position on December 2009 and December 2010 dividend swaps. Acting this way enables an investor to have a cumulative exposure to a potential mispricing in the dividend swaps. Nevertheless, if a mispricing arises, it may be difficult to tell which dividend swap is at the origin of the mispricing.

Thus, when there is more than one dividend flow, it does not seem possible to perfectly replicate the final dividend flow. That being said, both methods should lead to the same results as one gets the same exposure to a potential mispricing.

Once the implicit level of dividends that is priced by the market (i.e. using the replication strategy) is computed, we compare it to the levels of the dividend swaps. **The situation we consider is being short the dividend swap and long the replication portfolio** (made up of options with the same trade directions than in the put-call parity formula). Thus, if the difference is positive, it would seem theoretically possible to make a profit by selling the dividend swap and buying the replication portfolio. Conversely, if the difference is negative, it would seem theoretically possible to make a profit by taking a long position in the dividend swap and a short position in the replication strategy. The results are presented in **Table 2** in the next page.

Table 2. Amplitude of the mispricing for dividend swaps on the EuroSTOXX50 Index

	Minimum	<(5%)	(5%)-(3%)	(3%)-(1%)	(1%)-0%	0%-1%	>1%	Maximum	Total
Dec 09	(5.59%)	7	12	154	2,040	167	0	0.76%	2,380
		0%	1%	6%	86%	7%	0%		100%
Dec 10	(1.73%)	0	0	90	1,268	819	0	0.99%	2,177
		0%	0%	4%	58%	38%	0%		100%
Dec 11	(5.15%)	1	41	679	789	161	0	0.81%	1,671
		0%	2%	41%	47%	10%	0%		100%
Dec 12	(10.03%)	63	198	631	287	62	1	1.01%	1,242
		5%	16%	51%	23%	5%	0%		100%
Dec 13	(12.95%)	178	365	446	110	5	0	0.34%	1,104
		16%	33%	40%	10%	0%	0%		100%
Dec 14	(18.02%)	491	321	290	25	0	0	(0.29%)	1,127
		44%	28%	26%	2%	0%	0%		100%
Dec 15	(24.47%)	724	251	127	2	0	0	(0.88%)	1,104
		66%	23%	12%	0%	0%	0%		100%

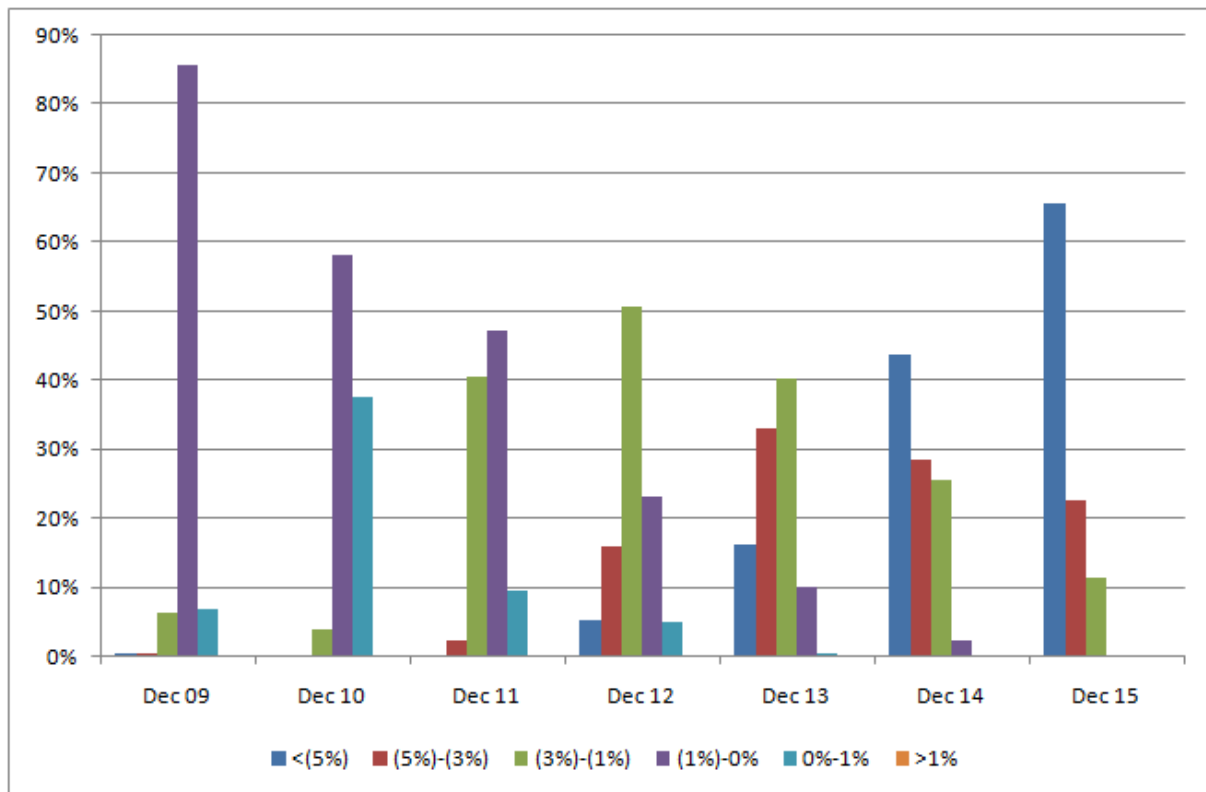
Source data: Eurex & Yahoo! Finance

As the number of available options on the EURO STOXX 50 Index and tradable on Eurex decreases with longer maturities, the number of replication strategies also decreases when the maturity of dividend swaps increases.

Table 2 shows the numbers of strategies that could replicate the dividend swaps and quantify the potential profit and loss for investors following the strategy described before. For instance, for the December 2010 row, over the 2,177 possible replication strategies (options with different strikes and different maturities), 1,268 lead to a difference in prices that is between minus 1.0% and 0.0%; 819 lead to a difference in prices between 0.0% and +1.0% and none lead to a difference in prices superior to +1.0%. The maximum loss of the strategy consisting in being short dividend swaps and long the replication portfolio for the December 2010 dividend swap is 1.73% and the maximum profit is 0.99%.

Thus, our findings reveal first that mispricing is persistent. Despite the fact that the market is aware that dividend swaps are mispriced, there is no arbitrageur to take advantage of such a situation. It would be interesting in a future study to understand the corresponding reasons.

Figure 4. Amplitude of the Mispricing for Dividend Swaps on the EuroSTOXX50 Index



Source data: Eurex & Yahoo! Finance

Another finding is that mispricing widens with the maturity of the swaps. As seen in **Figure 4** above, the difference in prices between the replication portfolio and the dividend swaps is less than minus one percent with 7% of available strategies for the December 2009 dividend swaps, 4% for the December 2010 dividend swaps and 43% for the December 2011 dividend swaps. This difference in prices is always inferior to minus 1.0% for December 2015 dividend swaps. Moreover, for all maturities, being short dividend swaps and long replication portfolio may look unprofitable on average. Thereby, for December 2015, 66% of the strategies may lead to results that have more than minus 5% of difference in prices. Thus it looks unrealistic to model such a strategy by a normal distribution as tails should look huge. Adopting the strategy short dividend swap and long replication portfolio should result in negative skewness for all maturities. Progressively, skewness becomes increasingly negative with longer maturities. As a result, the same strategy may have highly negative skewness for December 2014 and December 2015 dividend swaps.

Furthermore, the profits and losses of such a strategy soar with longer maturities: for December 2009, the P&L ranges between -5.59% and +0.76% and for December 2015, it ranges between -24.47% and -0.88%.

One potential explanation for these findings lays in the fact that dividend swaps listed on Eurex include only gross ordinary dividends i.e. *“unadjusted cash dividends declared and paid on that individual equity constituent of the index”*. Thus, these dividend swaps exclude special dividends, extraordinary dividends and return of capital payments because these adjustments are made directly to the EURO STOXX 50 Index. According to this definition, some potential adjustments may be included in any of the so-called replication portfolios but not in the dividend swaps. This could explain a part of the difference.

Another explanation may be found in the tax treatment of dividends for investors. As all investors do not face the same tax rate for dividends and for realized profit from financial products such as dividend swaps, one may consider that some of them should prefer paying a tax on “real” dividends (i.e. stemming from stocks) rather than on the profits resulting from a dividend swap. Thus, there may be a tax incentive for some investors to prefer what we called the “replication portfolio”, allowing them to get the same exposure to dividends. However, if this argument is valid, the replication strategy should always lead to the same results than the dividend swaps, adjusted by a constant factor. This factor should represent the difference of tax rate in the treatment of “real” dividends and the profit realized on dividend swaps. Unfortunately, as we can read in **Table 2** in page 18, there does not exist such a coefficient. So, despite the fact that this argument has to be taken into account, it does not explain all the price difference between the two strategies.

On the other hand, it should be interesting to consider the liquidity of dividend swaps. As we know, there exists a liquidity premium for products that are widely traded. For instance, the existence of a liquidity premium can explain the well-known arbitrage between on-the-run and off-the-run T-Bills. The same principle may be applicable in this case: As options and cash are liquid instruments from the investors’ point of view, a premium should be added to the replication strategy as it may be more liquid than the dividend swaps. In this case, we know that millions of options on the EURO STOXX 50 Index are traded each day. What about dividend swaps? In July 2008, Eurex estimated that daily dividend swaps turnover was almost EUR 1bn in over-the-counter markets.

Table 3. Daily Notional of Dividend Swaps on the EURO STOXX 50 Index listed on Eurex (EUR millions)

€m	Dec 09	Dec 10	Dec 11	Dec 12	Dec 13	Dec 14	Dec 15	Total
03/31/2009	8.2	36.3	24.2	0.1	3.5	0.0	0.0	72.2
03/30/2009	1.7	86.9	2.7	0.0	0.2	5.8	0.0	97.3
03/27/2009	0.9	70.3	26.6	0.0	0.0	0.8	0.0	98.6
03/26/2009	0.0	21.6	62.1	0.0	0.0	4.2	1.6	89.5
03/25/2009	0.6	30.9	3.0	1.7	0.0	0.0	0.2	36.4
03/24/2009	1.6	6.6	0.4	1.4	0.0	3.9	0.0	13.9
03/23/2009	0.0	3.6	1.0	0.0	7.6	1.9	0.0	14.1
03/20/2009	0.0	0.0	3.0	0.0	0.0	0.0	8.3	11.3
03/19/2009	0.8	12.8	17.0	3.2	0.6	7.2	2.7	44.4
03/18/2009	24.1	4.2	3.4	1.1	0.0	0.0	0.0	32.8
03/17/2009	3.5	2.3	4.9	3.9	0.0	0.0	0.0	14.6
03/16/2009	0.1	14.6	6.4	4.3	0.0	5.4	0.3	31.2
03/13/2009	0.8	7.5	19.4	8.9	0.0	0.6	0.0	37.2
03/12/2009	14.5	13.2	4.7	1.7	0.0	1.7	4.6	40.5
03/11/2009	16.5	6.2	21.4	2.8	0.0	0.3	0.0	47.3
03/10/2009	1.1	19.0	10.1	1.9	0.0	13.4	33.2	78.7
03/09/2009	0.9	10.6	0.0	3.4	0.0	0.3	1.3	16.5
03/06/2009	1.8	4.3	6.9	2.0	0.1	0.4	0.0	15.4
03/05/2009	13.0	46.2	0.4	0.0	0.0	0.1	0.0	59.7
03/04/2009	12.5	15.5	1.2	0.5	5.9	3.1	3.1	41.8
03/03/2009	0.0	0.0	0.3	2.2	0.0	1.8	1.6	6.0
03/02/2009	0.0	0.6	0.3	1.5	0.0	0.0	0.0	2.4
02/27/2009	83.5	5.7	17.2	0.0	1.5	0.0	0.0	108.0
Average	8.1	18.2	10.3	1.8	0.9	2.2	2.5	43.9

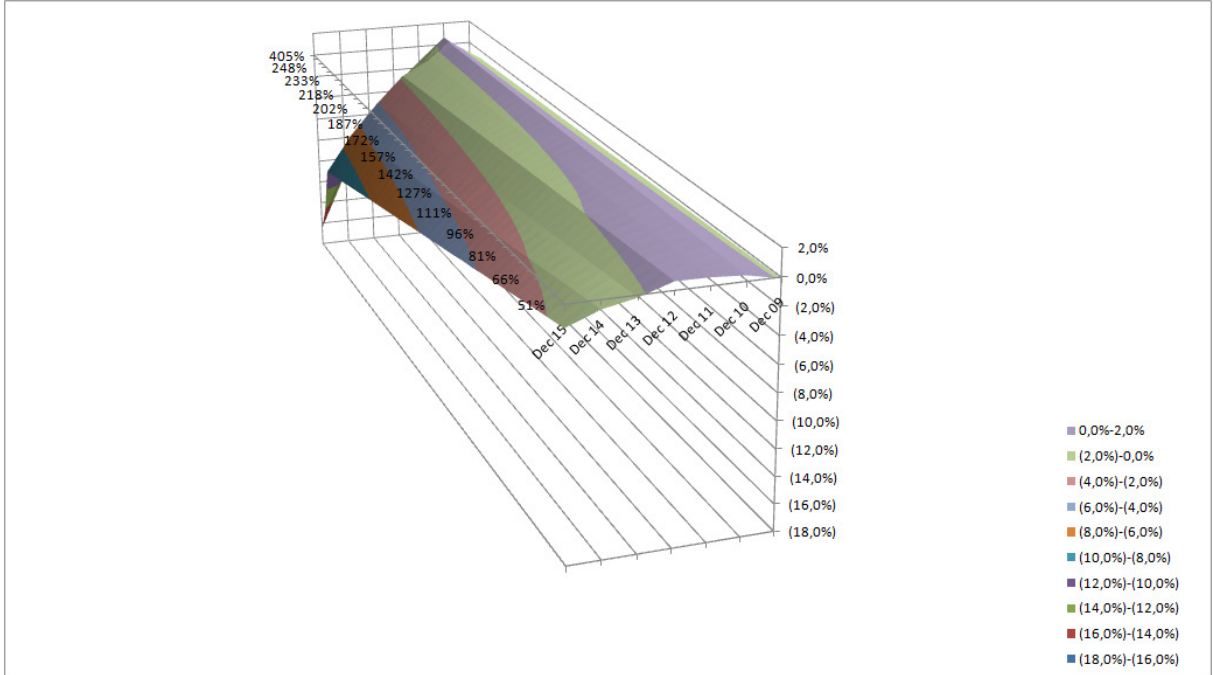
Source data: Eurex

Table 3 above shows daily data for dividend swaps on the EURO STOXX 50 Index traded on Eurex during the sample period. If the data is correct then these products represent 0.24% to 10.8% of the total daily dividend swaps turnover, with € 43.9m traded on average every day from February 27 to March 31, 2009. From these observations, the liquidity of dividend swaps does not seem to be a source of discrepancy in the pricing of dividend swaps compared to replication strategies.

However, we assumed before that options are uniformly liquid in a way that there are hundreds of thousands, or even millions of each type of options traded every day. Here again, it would be more reasonable to assume that options that have a strike price within a certain range around the level of the EURO STOXX 50 Index are more liquid than options that are far out-of-the-money or far in-the-money. Thus, we should pay particular attention to

where mispricing stems from. As the daily settlement price for options is not related to realized transactions (but from the Black-Scholes formula as stated previously), their bid-ask spreads should widen for strikes far from the level of the index. In addition, we do not have any information on the parameters that are taken into account by Eurex in option pricing. As a consequence, we can make the assumption that mispricing may arise when the dividend swap is replicated with options that are not liquid, i.e. with strikes far from the level of the EURO STOXX 50 Index. Thus, taking advantage of such a situation may be very difficult in practice. In order to address this issue, we compared the amplitude of the price discrepancies between the dividend swaps and replication strategies with all available options (every strike) for all maturities at a given date.

Figure 5. Discrepancy between the Dividend Swap and the Replication Portfolio (02/27/09)

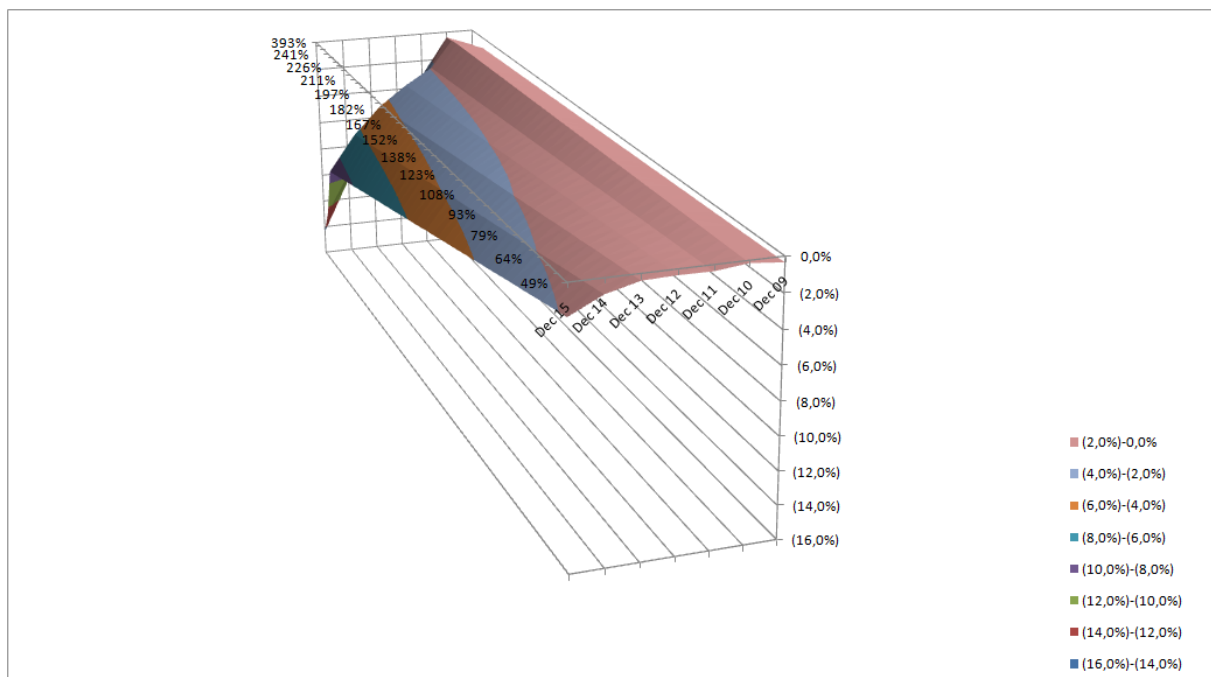


Source data: Eurex & Yahoo! Finance

Figure 5 shows the amplitude of the discrepancy between both strategies in percent of the daily level of the EURO STOXX 50 Index as of February 27, 2009 (the first day of our study) for all available dividend swaps replicated using options with strike prices that range from 51% to 405% of the level of the EURO STOXX 50 Index. We found that mispricing becomes larger with longer maturities and even more larger when the replication strategy is based on options having a strike price far above the level of the EURO STOXX 50 Index. For instance, the discrepancy between the replication strategy and the dividend swap ranges

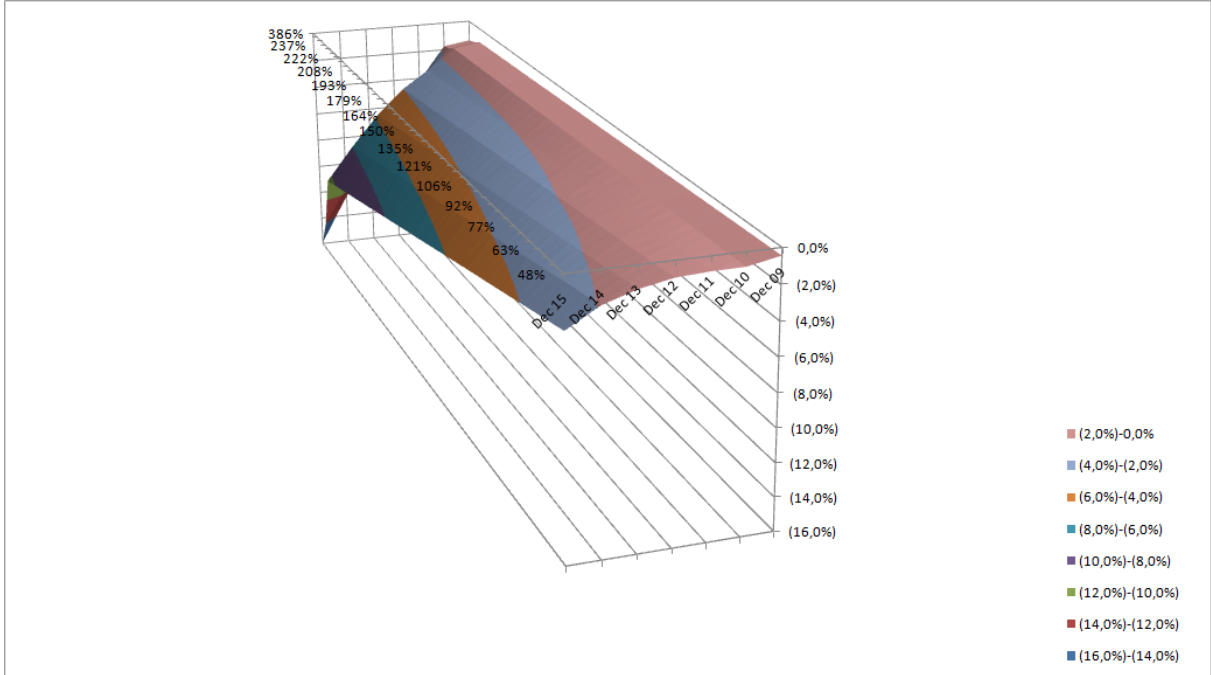
between -3.58% to +0.67% for maturities Dec-09 to Dec-12. As for Dec-13, replication of the dividend swap made with options that have a strike price far above the level of the index, i.e. more than 248% relative to the level of the EURO STOXX 50 Index, leads to a difference of more than -4.0%. It is interesting to notice in complement that for Dec-14 and Dec-15 maturities the discrepancy is small when the replication strategy includes options with strike prices that are below the level of the index and this discrepancy is getting wider and wider as options with strike prices higher than the index level are used for the replication of the dividend flow. The highest difference is found for maturity Dec-15 when options with a strike level of 8,000 (405% the index level of the EURO STOXX 50) are used for the replication of the dividend flow. Conversely, the smallest difference is found for maturity Dec-12 when options with a strike of 2,000 (101% the index level of the EURO STOXX 50) are used for the replication of the dividend flow. At mid-month and at the end of the month our conclusions are the same, as shown in **Figures 6** below and **7** in the next page, highlighting the amplitude of the discrepancies between both strategies in percent of the daily value of the EURO STOXX 50 Index for all available dividend swaps replicated using options with strikes that range from 1,000 to 8,000, i.e. 49% to 393% the index level of the EURO STOXX 50 as of March 16 and 48% to 386% the level of the EURO STOXX 50 Index as of March 31, 2009.

Figure 6. Discrepancy between the Dividend Swap and the Replication Portfolio (03/16/09)



Source data: Eurex & Yahoo! Finance

Figure 7. Discrepancy between the Dividend Swap and the Replication Portfolio (03/31/09)



Source data: Eurex & Yahoo! Finance

We did not find any significant difference between these three dates in the sense that largest discrepancies arise for longer maturities when the replication is made using options with strike prices that are far from the level of the EURO STOXX 50 Index. As it is fairly reasonable to assume that options with a strike price that is close the level of the index are more liquid than options with strike prices far above or below the level of the index, it seems that the liquidity of options used for the replication of the dividend flow can have a significant impact on the discrepancy between replication strategies and the level of the dividend swaps.

In order to check whether the use of index options with strikes far from the level of the EURO STOXX 50 Index has a real impact on the amplitude of the difference in price levels, we decided to compare the revenue an investor could expect to earn if she chooses to be constantly short dividend swaps and long the replication portfolio made up exclusively of index options that have strike prices below, at, or above the level of the EURO STOXX 50 Index. To compare such strategies, we choose to constantly replicate the dividend flow with options that have strike levels equal to 1,000, 1,800, 2,000, 2,200 and 7,000. Note that the level of the EURO STOXX 50 was between 1,810 and 2,157 index points during the period of our study. With this experiment, we could assess whether liquidity is at stake when it comes

to replication: If the use of options with a strike price far above or far below the index level the EURO STOXX 50 lead to results that are significantly different from those we get with options that have strike levels more or less equal to the level of the index, we could conclude that liquidity has an effect on replication and this effect cannot be neglected. Results are shown in **Figures 8 to 12** in Appendix.¹⁴ For all dates, we note that all replication strategies give more or less the same prices than dividend swaps for the 2009, 2010, 2011 and 2012 dividend flows. However, we noticed that the discrepancy is getting increasingly wider with (i) the maturity of the options (the higher the maturity, the wider the discrepancy) and (ii) their strikes (the more they are away from the level of the EURO STOXX 50 Index, the higher the discrepancy). It seems that dividend swaps listed on Eurex globally undervalue the level of dividends for a given year in comparison to the dividend level priced by the market. The discrepancy widens with longer maturities and when the replication strategy relies on options that have a strike price which is far above the level of the EURO STOXX 50 Index.

As a result, as options with strikes far from the level of the index are less liquid than at-the-money options, and as the discrepancies between replication strategies and dividend swaps widen when the former are based on options with strike prices far above the level of the EURO STOXX 50 Index, liquidity may have a significant impact on the replication of the dividend flow. For that matter we tried to address this issue by adding bid and ask spreads to option prices and dividend swaps. As the EURO STOXX 50 Index is very liquid, we considered that such procedure was not necessary for this product.

2.2.2. Addressing main pitfalls

In the following part of our study, we try to address all issues that affect transaction prices or strategies' returns in reality. We chose to take a step back from our previous theoretical approach. It appears that the previous study relied on two strong assumptions that are not necessarily true in practice.

¹⁴ We changed scale for figures 11 and 12 and used 2% units instead of 1% for sake of clarity

First, we used the so-called “settlement prices” for options and for dividend swaps on the EURO STOXX 50 Index. But we saw that liquidity is a real issue for such products, especially for dividend swaps and options that are far in and out-of-the-money. So we had to reflect it somehow in our study. As we did not have easy access to such data we contacted investment bank insiders in order to obtain the spreads for dividend futures and options over the sample period. As a result, we applied the following spreads¹⁵:

Product	Spread
Dividend Futures	10%
ATM Options	1.5%
25% ITM Options	2.0%
25% OTM Options	10%

In order to replicate reality accurately we ignored options that have strikes below 1,000 and above 3,000 index points. Using the data summarized in the array above, we computed bid and ask prices for options and dividend swaps on the EURO STOXX 50 Index. We then computed the implicit level of dividend that we can obtain using what we called before the “replication strategy”. Due to the existence of the bid-ask spread, we get different levels of dividend whether we replicate a long or a short position in dividend.¹⁶

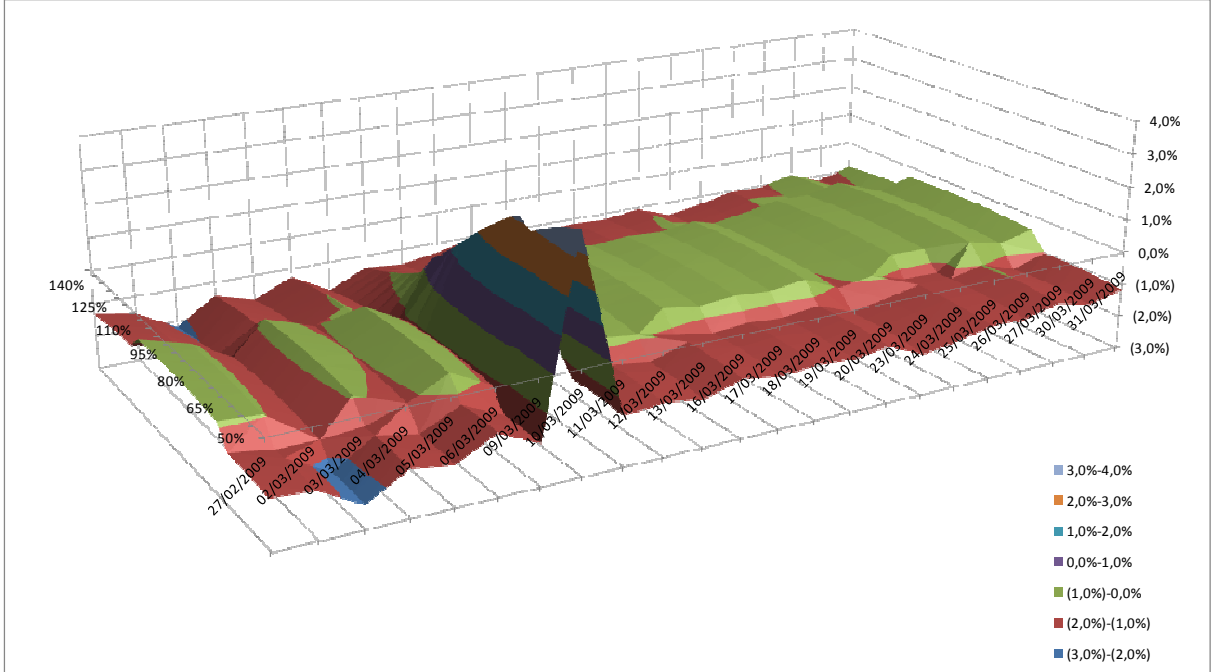
We compared the levels obtained to those of the dividend swaps. A mispricing appears (i) if the bid price of the dividend swap exceeds the implied level of dividend obtained by replication of a long position dividend or (ii) if the ask price of the dividend swap is less than the implied level of dividend obtained by replication of a short position in dividend. In order to avoid a potential problem caused by the existence of intermediary dividend flow(s), we decided to focus on December 2009 dividend swaps. As shown in **Figures 13 and 14** in the next page, we found that a strategy consisting in buying the dividend swaps and selling the replication portfolio leads to a maximum potential gain of 3.73% and a maximum loss of 2.32% of the level of the EURO STOXX 50 Index with an average loss of 0.94%. On the other hand, a strategy consisting in selling the dividend swap

¹⁵ Data provided by Mr. Nicolas Mougeot, Research Derivative Department, Deutsche Bank (April 2009).

¹⁶ We adjusted the put-call parity for dividend paying stocks at time t with bids and asks. Depending on the direction of the trade, we have: Long $PV(Div)_t = S_t + P_{Ask,t} - C_{Bid,t} - PV(K)_{t,T}$, and Short $PV(Div)_t = C_{Ask,t} + PV(K)_t - S_t - P_{Bid,t}$, where as usual PV stands for present value, Div for the dividend payment, S for the stock price, P for the put price, C for the call price and K for the strike.

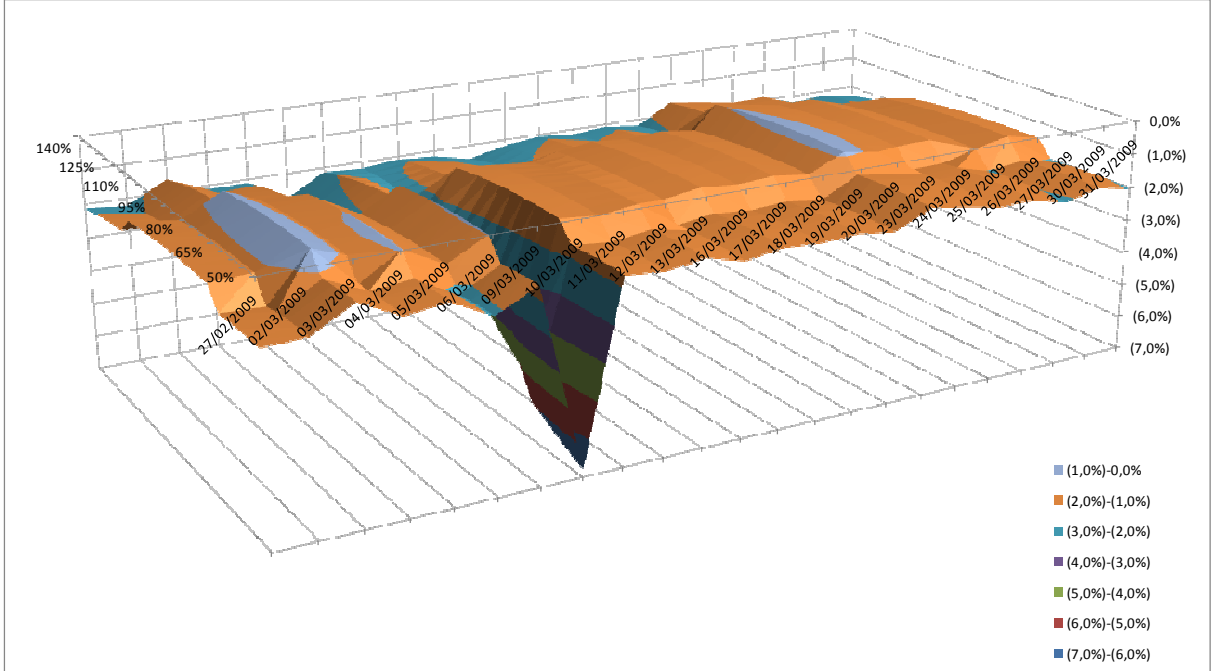
and buying the replication portfolio always leads to a loss up with a minimum loss equal to 0.50% and a maximum loss of 6.77%.

Figure 13. Long dividend swap and short adjusted replicating portfolio (maturity Dec-09)



Source data: Eurex & Yahoo! Finance

Figure 14. Short dividend swap and long adjusted replicating portfolio (maturity Dec-09)

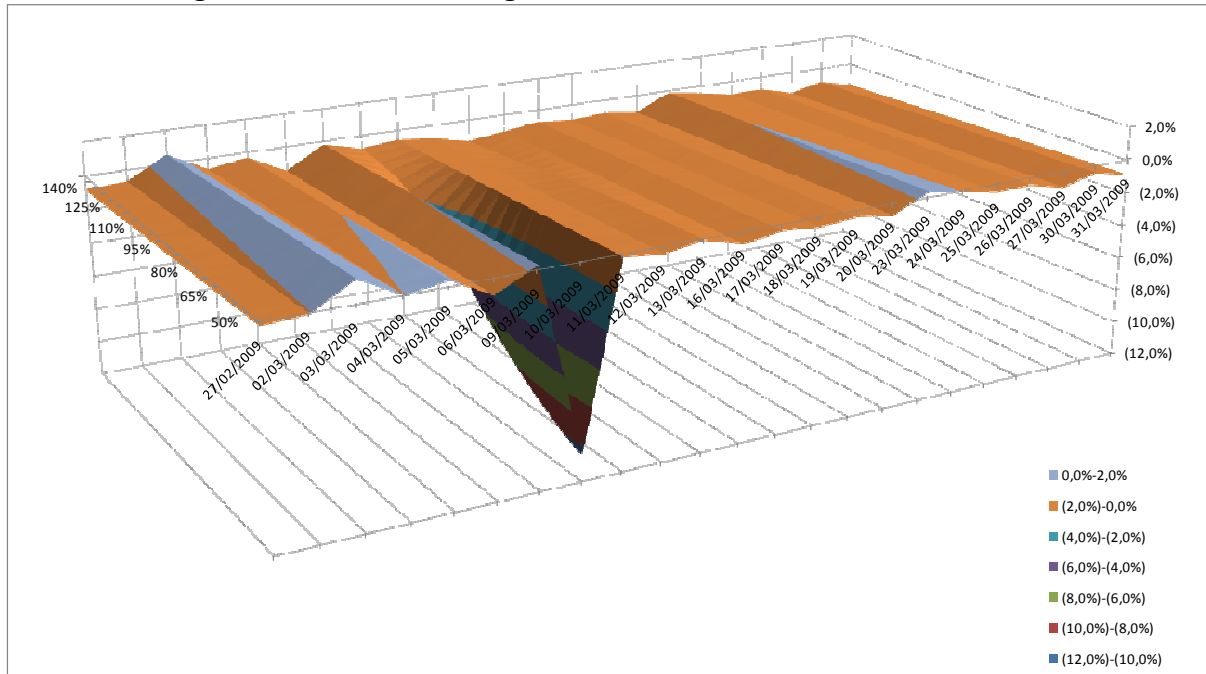


Source data: Eurex & Yahoo! Finance

We note that the two strategies follow an opposite pattern - a sharp increase for the first strategy and a sharp decrease for the second strategy - on March 10, 2009 for options

with a strike price far below the level of the EURO STOXX 50 Index and a relatively flat trend otherwise. We found no rational explanation for this peak.

Figure 15. Difference in % of the level of the EURO STOXX 50 Index of the strategy described in figure 14 minus that of figure 13



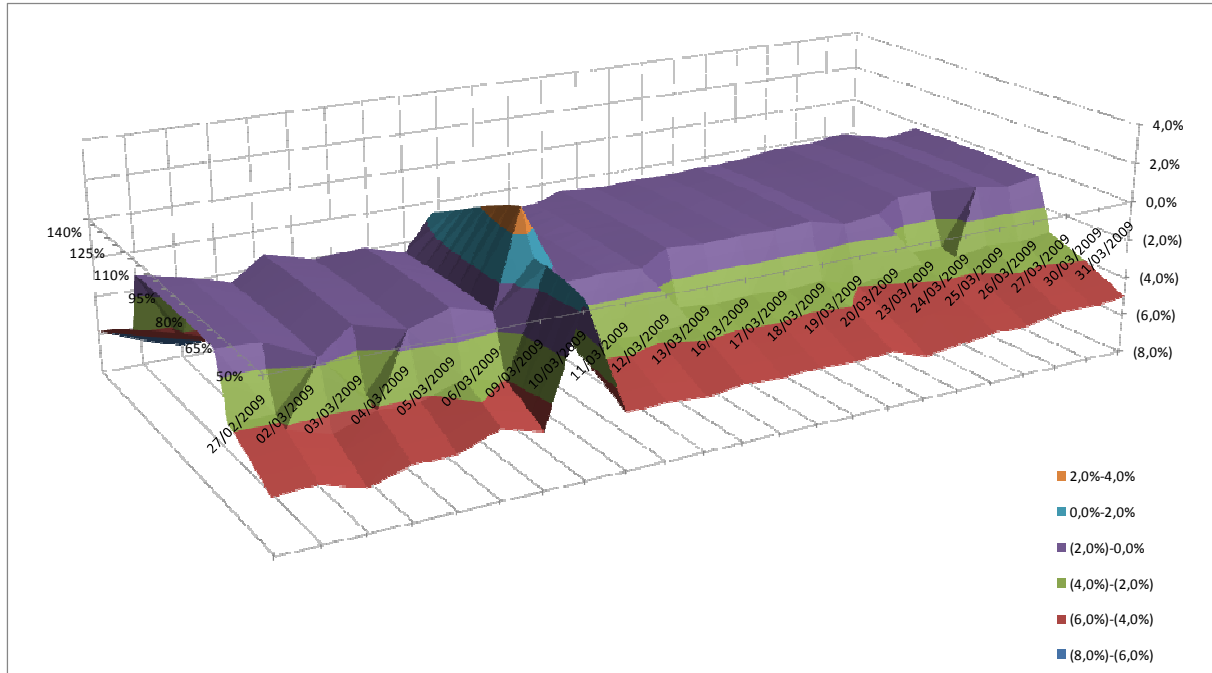
Source data: Eurex & Yahoo! Finance

Moreover, **Figure 15** shows that the strategy consisting in long short dividend swap and short replication portfolio is systematically better than the strategy consisting in being short dividend swap and long replication portfolio because the difference between both strategies is almost always negative.

One reason for such a discrepancy can be found in the assumption that spreads are not symmetric, i.e. spreads for OTM and ITM options are not the same. Note that some traders consider that spreads should be symmetric. Thus, we also considered the following spreads:

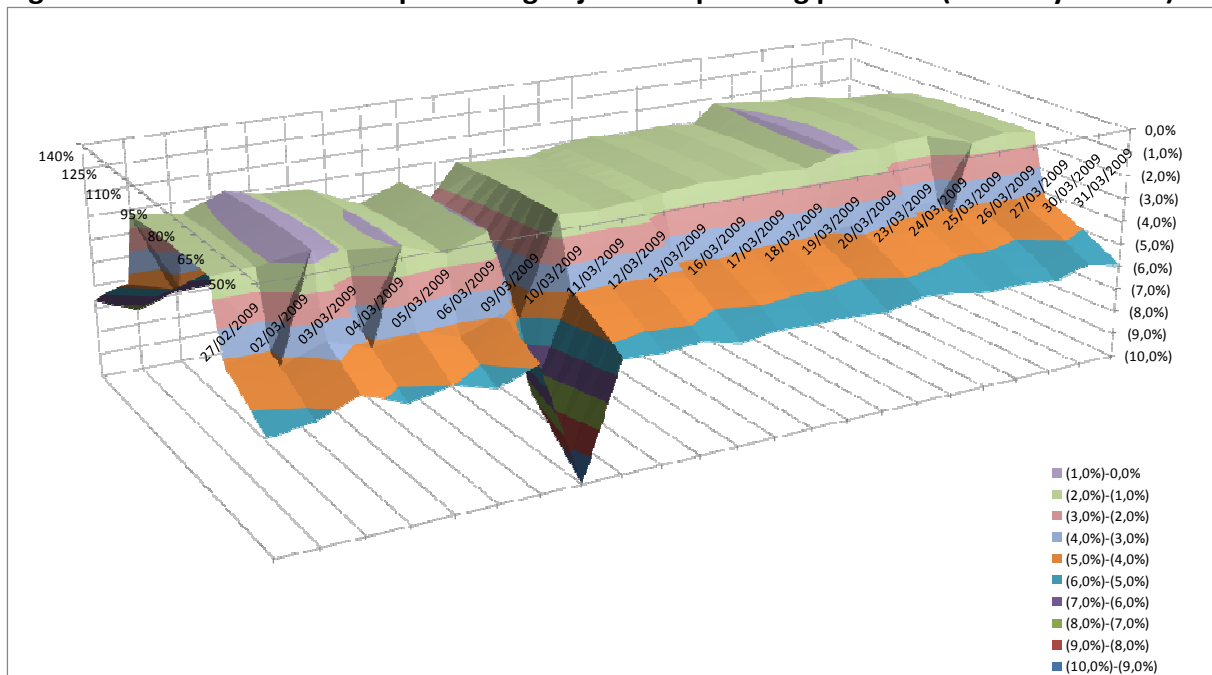
Product	Spread
Dividend Futures	10%
ATM Options	1.5%
25% ITM Options	10%
25% OTM Options	10%

Figure 16. Long dividend swap and short adjusted replicating portfolio (maturity Dec-09)



Source data: Eurex & Yahoo! Finance

Figure 17. Short dividend swap and long adjusted replicating portfolio (maturity Dec-09)



Source data: Eurex & Yahoo! Finance

We found that a strategy consisting in buying the dividend swaps and selling the replication portfolio leads to a potential maximum gain of 3.15% and to a maximum loss of 7.58% of the level of the EURO STOXX 50 Index with an average loss of 2.68%. So, a rise in the spreads of ITM options increases the average return of such a strategy. However, the return is still

negative on average. On the other hand, a strategy consisting in selling the dividend swap and buying the replication portfolio always leads to a loss up to 9.96%. Moreover, returns of strategies built on OTM or ITM options are negative and symmetric in this case.

We did the same experience for dividend swaps maturing in December 2010. In order to detect potential mispricing, we had to tackle the issue of the intermediary dividend flow, i.e. dividend flows for 2009. Adjusting the formula we've seen in the previous subsection with bids and asks, we obtain:

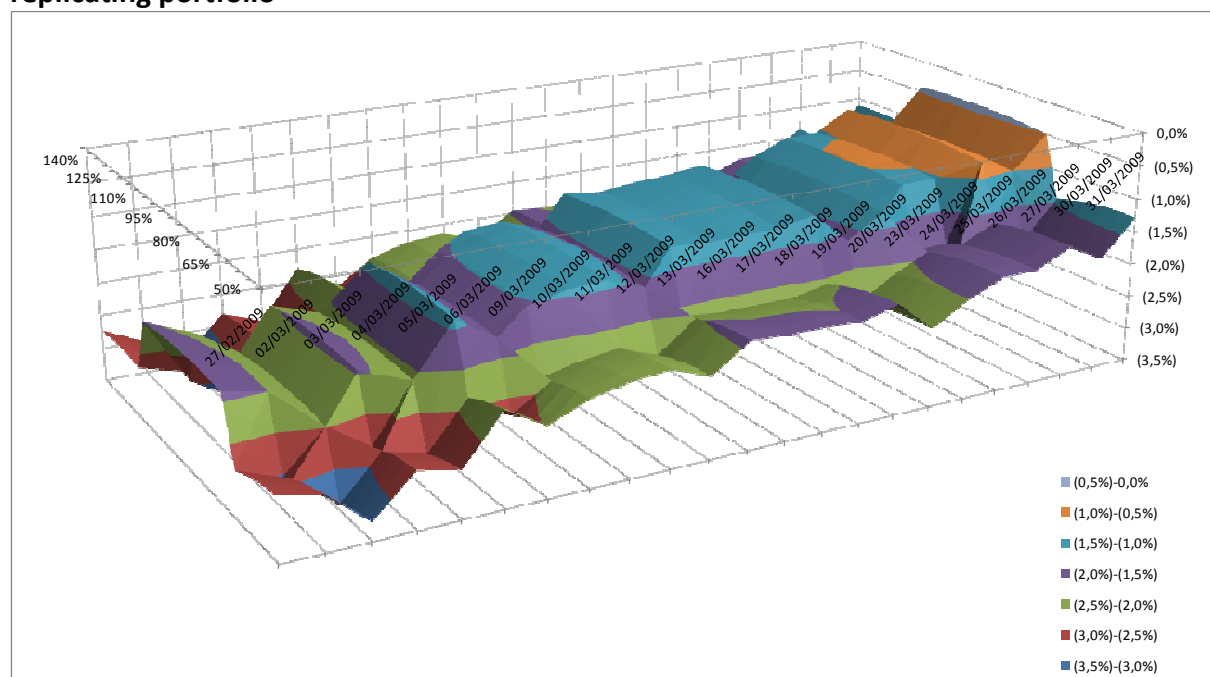
$$PV(\text{Div}_{2009})_t + PV(\text{Div}_{2010})_t = S_t + P_{\text{Ask},t} - C_{\text{Bid},t} - PV(K)_t$$

Leading to: $PV(\text{Div}_{2010})_t = S_t + P_{\text{Ask},t} - C_{\text{Bid},t} - PV(K)_t - PV(\text{Div}_{2009})_t$

As a proxy for $PV(\text{Div}_{2009})$ we used the December 2009 dividend swap. So, in order to replicate a long position in the 2010 dividend, one has to sell the December 2009 dividend swap (negative sign in the above formula). Thus, we use its bid price. Conversely, when replicating a short position in the 2010 dividend, one has to buy the December 2009 dividend swap. Thus, we use the ask price. Note that we used non symmetric spreads.

The first strategy consisting in taking a long position in the dividend swap and a short position on the level of the dividend using the replication portfolio leads to the following results.

Figure 19. Long position in the 2010 dividend swap and short position in the corresponding replicating portfolio

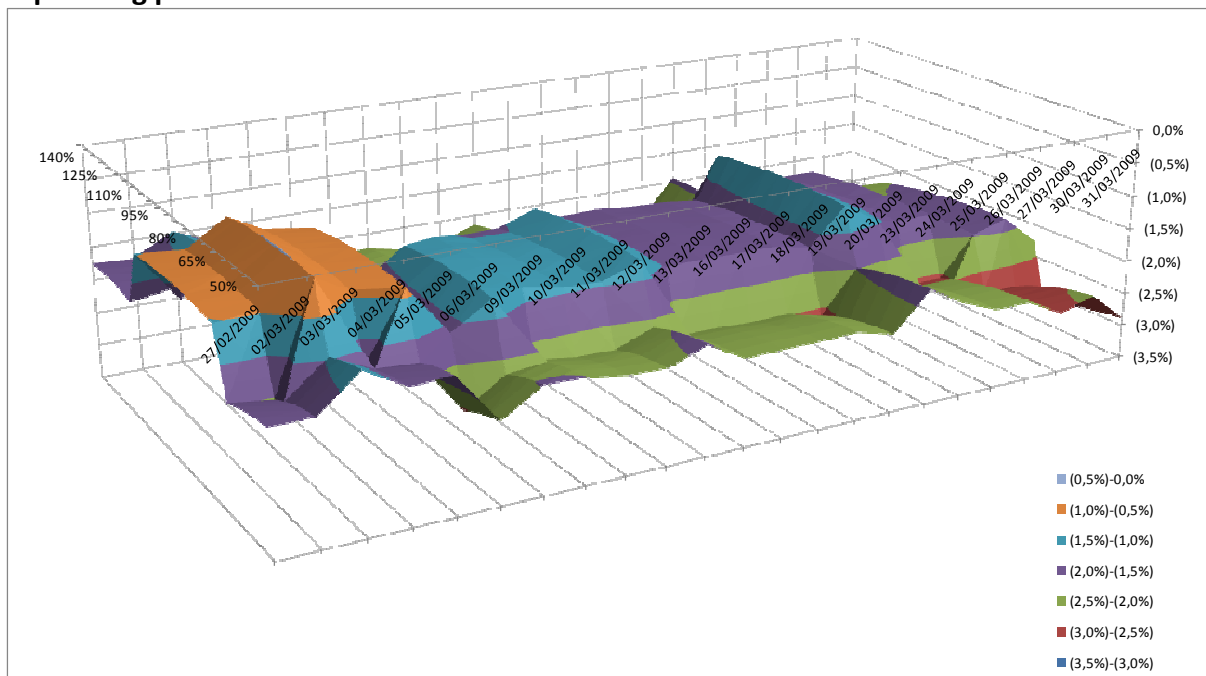


Source data: Eurex & Yahoo! Finance

Here again, we found that not even one arbitrage opportunity arises from the previous strategy due to the existence of bid-ask spreads. Indeed the low liquidity induces a huge bid-ask spread that wipes out mispricing in favor of the investors, as shown in **Figure 19** above.

Now, let's have a look at the strategy consisting in taking a short position in the dividend swap and a long position on the level of the dividend using the replications strategy. Results are shown in **Figure 20**.

Figure 20. Short position in the 2010 dividend swap and long position in the corresponding replicating portfolio



Source data: Eurex & Yahoo! Finance

By using such a strategy, a trader cannot make any profit over the period. On average, a trader following this strategy would lose 1.84% of his investment according our analysis.

In short, in our first approach we found that significant arbitrage opportunity may appear on dividend swaps on the EURO STOXX 50 Index, validating the study of Wilkens and Wimschulte. However, in complement, we can say that the relatively low liquidity illustrated by subsequent bid-ask spreads seem to make them disappear. Some opportunities remain but they look much less attractive than before with a potential profit up to 3.73%, excluding

transaction costs and funding issues. Moreover, as profitable as any strategy may prove to be, there is a strong timing component.

The second pitfall we wanted to address in our study is the assumption we made that investors have access to particularly attractive funding conditions. We decided to focus mainly on December 2009 dividend swaps for which investors initially benefit from Libor 9m as funding rate. This approximation has to be clarified, in particular when liquidity is at stake. In order to address this issue, we considered two situations:

- For the strategy consisting in taking a short position in the dividend swap and a long position on the level of the dividend using replication, investors are mainly short cash. Thus, a decrease in the interest rate should increase the return of the strategy. In order to study the impact of a decrease in the interest rate, we tried to find the optimal (negative) spread over Libor 9m that an investor should enjoy in order to make a profit on average. Unfortunately, it is not possible to find an optimal interest rate that makes this strategy profitable on average, as this so called optimal interest should be negative.¹⁷
- For the strategy consisting in taking a long position in the dividend swap and a short position on the level of the dividend using replication, investors benefit from an increase in the interest rate because of the long cash position. Thus, an increase in the interest rate should also increase the return of the strategy. We found that with an interest rate of LIBOR 9m + 1.19%, investor can make this strategy profitable on average.

Interest rates are at stake when it comes to replicate the dividend flow using a portfolio of options. In order to solve this problem, we tried to find the optimal interest rate that makes a strategy profitable on average. Unfortunately for potential investors, we found that no realistic funding conditions would allow them to make a profit on average with the strategy consisting in taking a short position in the dividend swap and a long position on the level of the dividend using replication. Should an investor adopt the opposite strategy, he could make a profit on average if he can get a rate of LIBOR 9m + 1.19% for both, his funding and his long cash position.

¹⁷ Source: British Bankers Association: www.bba.org.uk

CONCLUSION

As replication of dividend flow is relatively easy for investors due mainly to a high level of liquidity of the financial tools needed (which are mainly options), dividend swaps on the EURO STOXX 50 Index seem to offer arbitrage opportunities. On a first approach, we found that significant mispricing appears, in particular for dividend swaps with longer maturities and when replication is made with options far in or far out-of-the-money. Looking at the results in details, we found that opportunities appear where liquidity is at stake. We then tried to address this issue by adding a bid-ask spread to derivatives used for the replication strategy. We thought that such procedure was not necessary for the EURO STOXX 50 Index, as this product is widely traded. As for dividend swaps and options on the EURO STOXX 50 Index, we added up to a 10.0% spread to the settlement price. By adding such spreads, we found that mispricings almost completely disappear and that the remaining opportunities that arise lead to smaller profit than before (up to 3.73% before transaction costs and funding spread). Moreover, should an investor want to take advantage of the situation, there is a strong timing component. As for the funding spread, we found that the strategy consisting in taking a short position in the dividend swap and a long position on the level of the dividend using replication mainly benefit from a decrease in the interest rate. We also found that no realistic funding conditions would allow an investor to make a profit on average for this strategy. On the other hand, with the opposite strategy, an investor could make a profit on average if he can get a rate of LIBOR 9m + 1.19% for both, his funding and his long cash position.

Looking forward

The aim of our study was to quantify potential arbitrage opportunities on a newly listed product. We found that opportunities are relatively limited and do not allow investors to make substantial profit.

However, there is still some room for improvement, in particular on the following points:

- ⇒ Our study may be affected by sample selection and time-period biases. We indeed excluded dividend swaps maturing after December 2015 since they were not listed during our study. Moreover, we conducted our study over a very short period of one month which may lead to time-specific results. Thus, there is still room to conduct a study on more comprehensive data over a longer period.
- ⇒ The spread on options and dividend swaps we used are average spreads given by professionals. It could have been more appropriate to use daily quoted bid-ask spread on such products in order to improve data accuracy.
- ⇒ We did not take into account transaction costs because they are very small relative to bid-ask spreads. However, due to the complexity of what we called the replication strategies, they can represent a substantial amount of money per trade. Thus, some potential opportunities can be completely unwound by the existence of transaction costs, making potential profit even more difficult to capture.
- ⇒ Should the data be available, it could be interesting to study tick by tick data, because of potential opportunities that could arise all along the trading day.
- ⇒ One of the main issues we tried to address is the treatment of intermediary dividend flows. All along the study, we considered that dividend swaps are a good proxy for intermediary dividend flows. On the other hand, we are aware that some mispricing may appear regarding dividend swaps. Thus, we limited our in-depth study to dividend swaps maturing in December 2009. Unfortunately, the first approach suggested that significant opportunities arise for dividend swaps having longer maturities. Further research should be necessary to address this issue.

ACKNOWLEDGMENT

We thank very much Mr. Christophe Perignon for his availability, his guidance and his encouragements. We hope our study answered his curiosity on the subject.

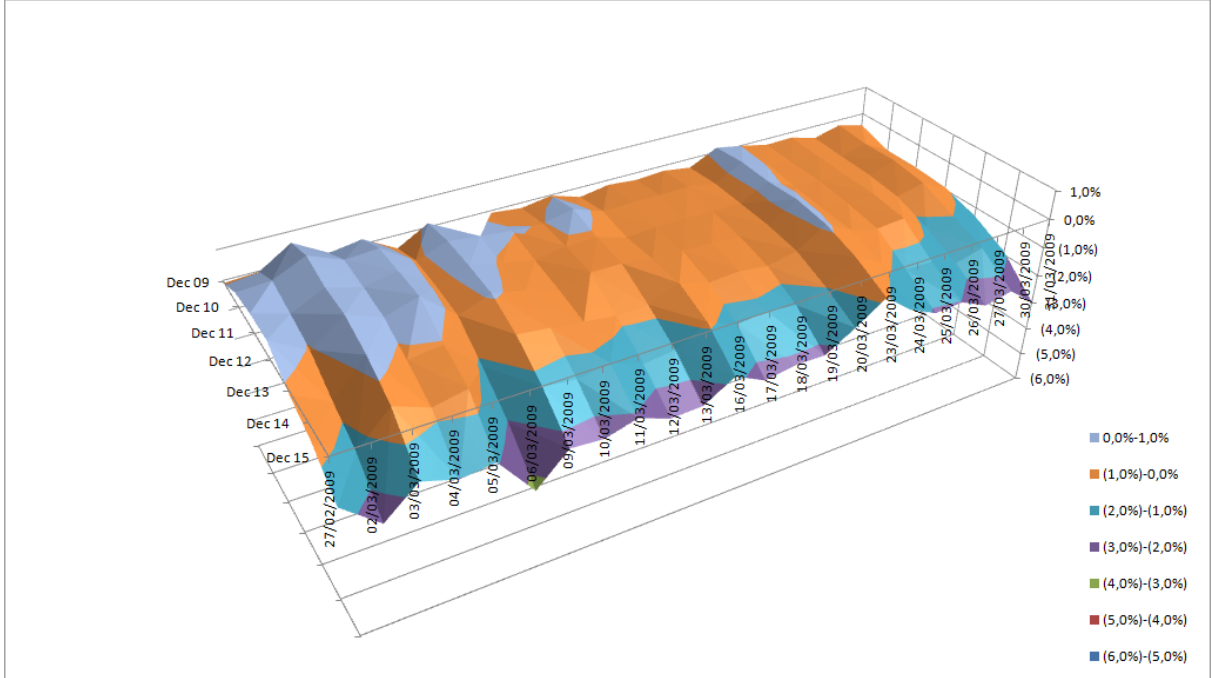
We would also like to thank the professionals who helped us have a better understanding of the dividend markets and products, especially Mr. Nicolas Mougeot (Managing Director – Research department at Deutsche Bank) whose course on hidden assets led us to do this thesis, Mr. Ali Bassit (former trader at JPMorgan & Chase), Mr. Gabriel Messika (trader Equity and Derivatives at BNP Paribas) and Mr. Jean-Paul Corda (salesman at Goldman Sachs International) who provided us valuable information.

REFERENCES

- ◆ Black, Fisher. 1976. "The Dividend Puzzle". *Journal of Portfolio Management*. Winter issue. Pages 5 to 8.
- ◆ Brennan, Michael J. 1998. "Stripping the S&P 500 Index". *Financial Analysts Journal*, vol. 54, no. 1 (January/February). Pages 12 to 22.
- ◆ Deutsche Börse. April 22, 2009. "Eurex to enhance successful Index dividend future contract". Press release.
http://deutsche-boerse.com/dbag/dispatch/en/notescontent/gdb_navigation/press/10_Latest_Press_Releases/30_Eurex/INTEGRATE/mr_pressreleases?notesDoc=23B6661D78A82B46C12575A000280655&newstitle=eurextoenhancesuccessfulindexd&location=press
- ◆ Eurex. July 2008. "Eurex Dow Jones Euro STOXX 50 Index Dividend Futures – Pricing & Applications for the Institutional Investor". Brochure.
http://www.eurexchange.com/download/documents/publications/study_djeuroSTOXX50_div_fut.pdf
- ◆ Fama, Eugene F., and Kenneth R. French. 2001. "Disappearing dividends: Changing Firm Characteristics or Lower Propensity to Pay?". *Journal of financial economics*, vol. 60. Pages 3 to 43.
- ◆ Goldman Sachs. September 2006. "US Portfolio strategy – Turning cash into value". Research paper. Unknown author.
<http://www2.goldmansachs.com/ideas/portfolio-strategy/us-portfolio-turning-cash-pdf.pdf>
- ◆ Gordon, M.J., and E. Shapiro. October 1956. "Capital Equipment Analysis: The Required Rate of Profit". *Management Science*, vol. 3, no. 1. Pages 102 to 110.
- ◆ Manley, Richard, Mueller-Glissman Christian. 2008. "The Market for Dividends and Related Investment Strategies". *Financial Analysts Journal*, vol. 64, no. 3. Pages 17 to 29.
- ◆ Stoxx Ltd. October 2008. "Dow Jones EURO STOXX 50 Dividend Points Calculation Guide".
http://www.stoxx.com/download/indices/rulebooks/calculation_guide_dvp.pdf
- ◆ Wilkens, Sascha, and Jens Wimschulte. February 2009. "The pricing of dividend futures in the European market: A first empirical analysis". Working paper, submitted for publication. London/Cologne.
http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1350788

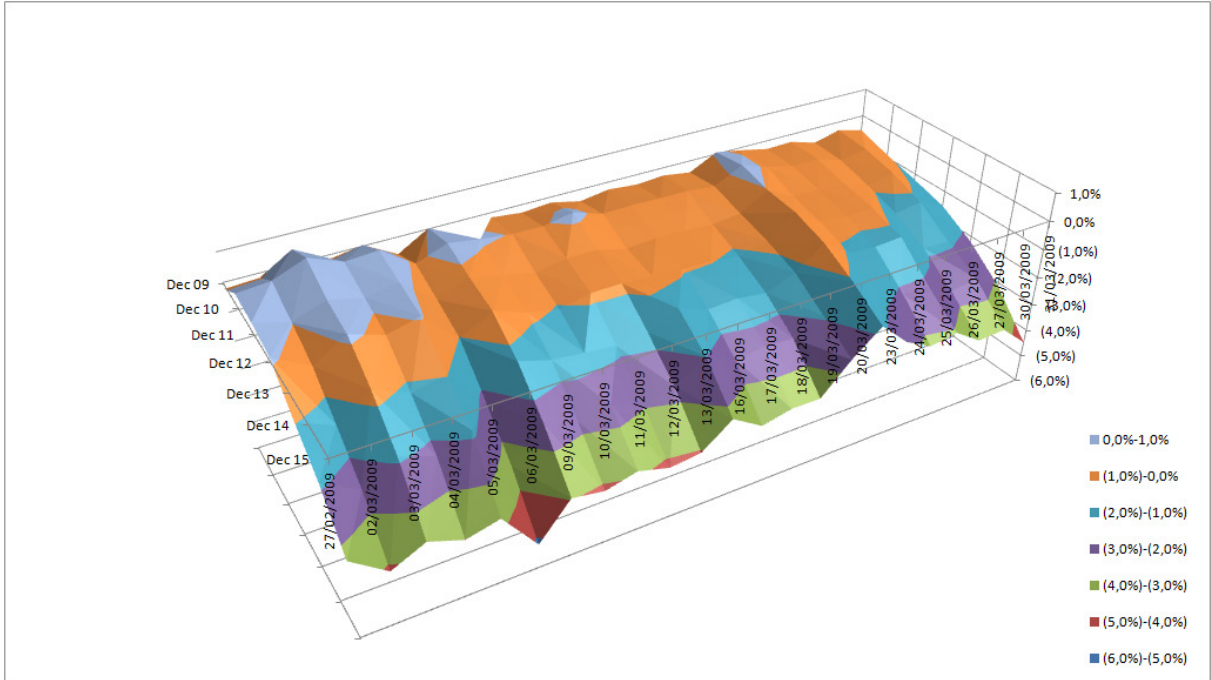
APPENDIX: Additional graphs which show our results

Figure 8. Dividend Swap vs. Replication Strategy using options with strike of 1,000



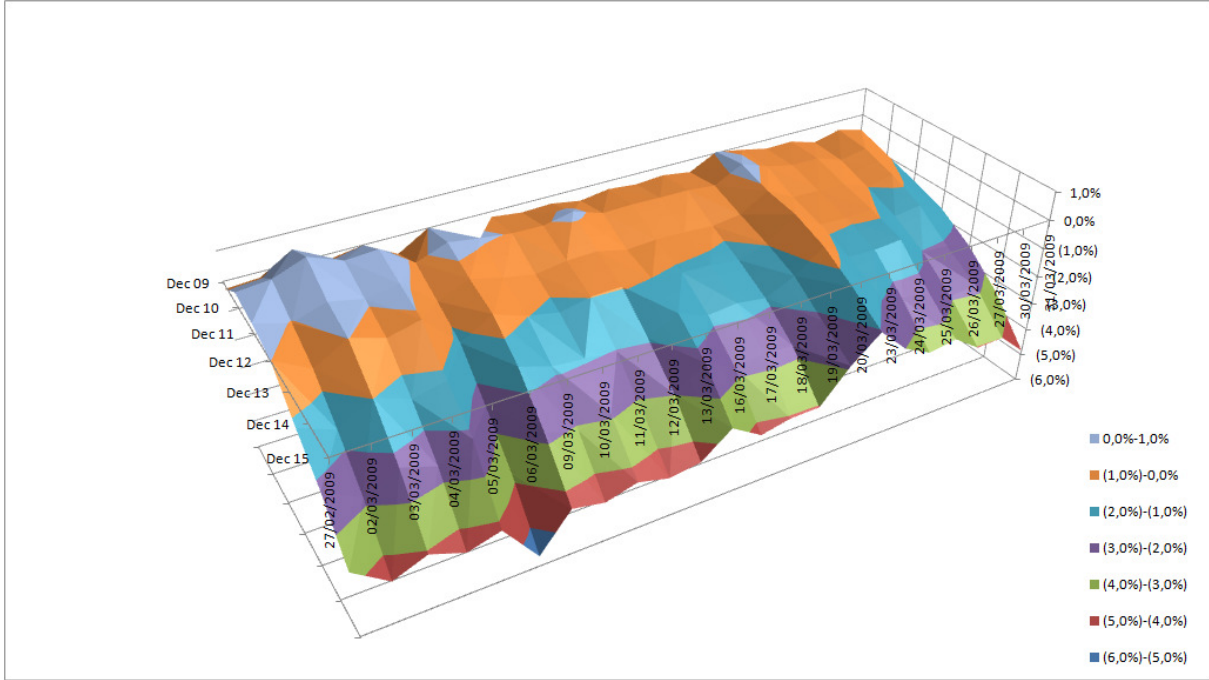
Source data: Eurex

Figure 9. Dividend Swap vs. Replication Strategy using options with strike of 1,800



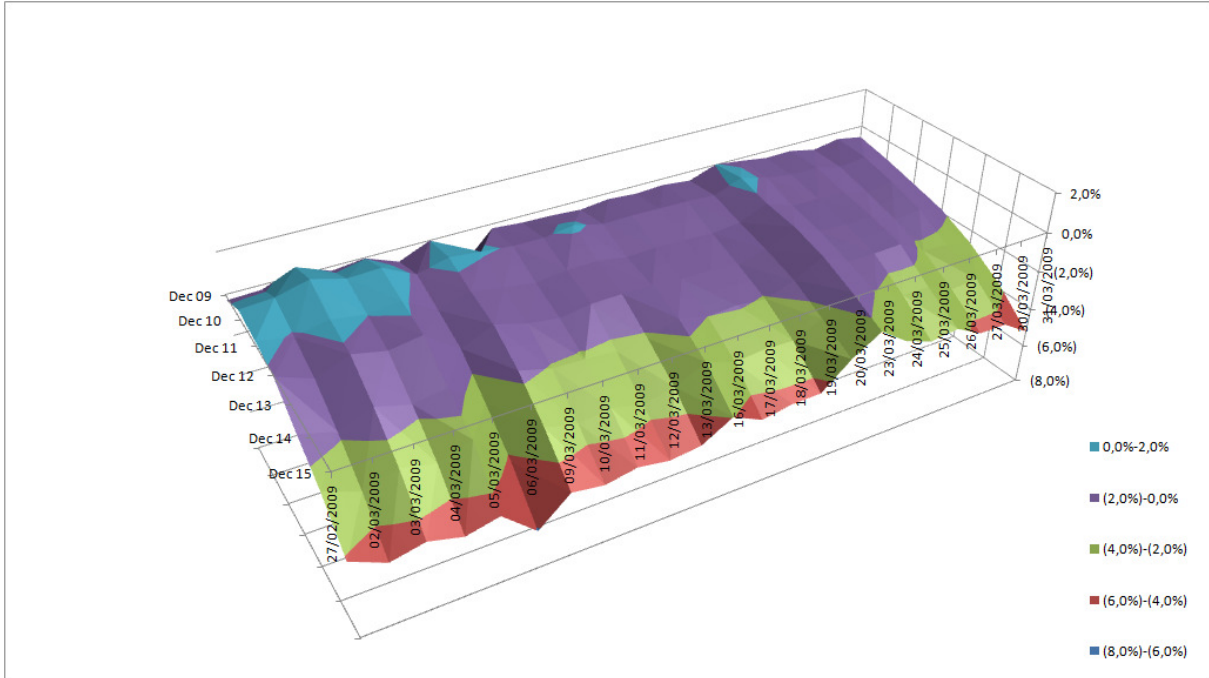
Source data: Eurex

Figure 10. Dividend Swap vs. Replication Strategy using options with strike of 2,000



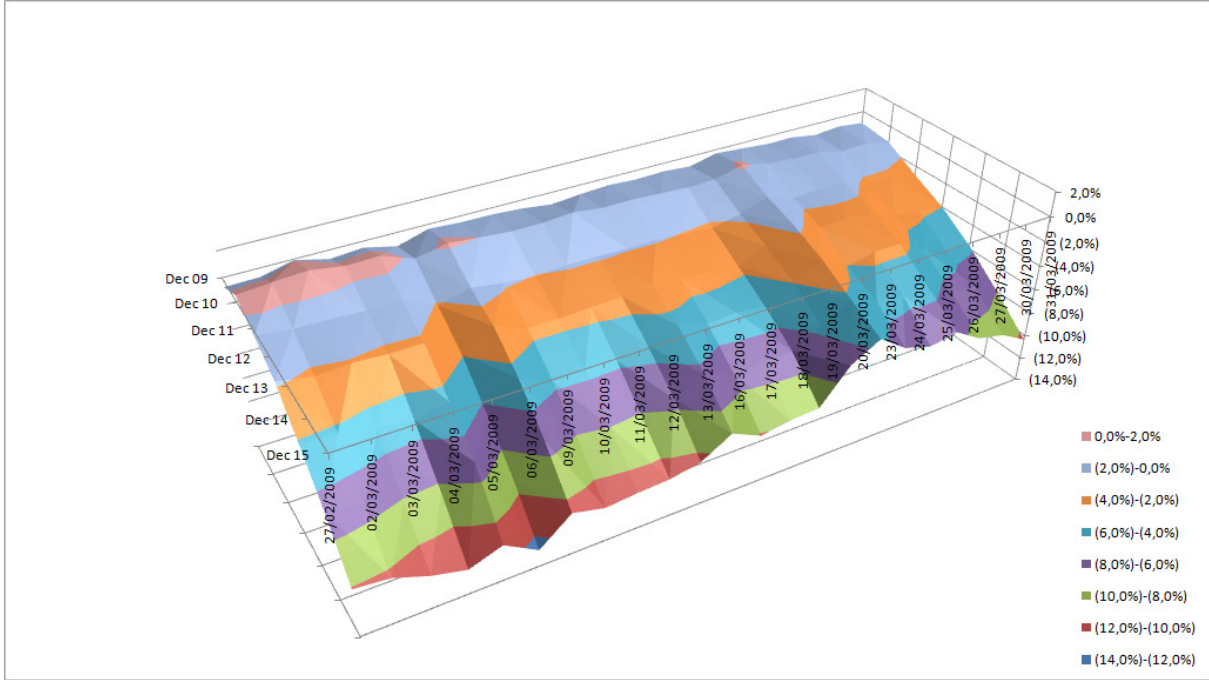
Source data: Eurex

Figure 11. Dividend Swap vs. Replication Strategy using options with strike of 2,200



Source data: Eurex

Figure 12. Dividend Swap vs. Replication Strategy using options with strike of 5,000



Source data: Eurex