Structured Bonds and Greek Demons

Is the attack "fair"?

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Abstract

The severe political turmoil provoked by an allegedly mispriced private bond issue in Greece added to the controversial matter of whether prices of structured bonds sold to investors are "fair" or not. In this paper structured bond market is analysed with particular focus on valuation issues. It is argued that in practice prices are subjective, there is not a unique price that a structured bond should be transacted and model prices are in general irrelevant to the investor unless he has access to the underlying swap market. Consequently, the notion "overpricing" (conventionally defined as the difference between model and transacted price) is misleading. Boundaries for prices as seen by investors and issuers are constructed under a set of simplified assumptions. Issue price is the recommended price that a structured bond should be offered in the primary market and in most cases differs from model price. Competition among issuers should minimize the difference between them. The analysis of the market in Greece has revealed investors' preferences to capital guaranteed interest rate linked bonds with mild structuring. Despite popular belief, overpricing was soft with the absence of the usual

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marketing pitfalls that happened elsewhere. Exception were the Tier I
structured bonds issued by local banks.

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1   Introduction

Structured Bonds (SBs) have been a phenomenal success story since the last
decade. Although before 2000 the global volume had been around 15 bln EUR
and professional investors had been the main buyers of these bonds, after
2000 retail investors have started to step into this market. In 2010 global vol-
ume exceeded half a trillion EUR. SBs combine fixed income and derivatives
characteristics and as a result they are extremely popular among all investors'
classes. By buying these bonds, investors access markets traditionally reserved
for investment banks and sophisticated funds. Investors are exposed to risks
and returns normally prohibitive to them for various reasons such as lack of
financial expertise, size, regulatory constraints, etc. SBs are flexible in their
design and can be tailor-made to investors' specific needs. Structurers and
suppliers of these bonds usually create demand for these products through the
supply chain by casting to market new ideas depending on market conditions.
Aggressive marketing is not uncommon since profit margins for all the involved
parties (issuers, arrangers, intermediaries) are much higher than margins from
other traditional forms of investments such as equities, fixed/floating bonds,
(simple) listed derivatives, etc.. Even academics praise and advertise SBs as
necessary tools for market completion and yield enhancement [64]. SBs that
were launched in Greece were mainly confined to bonds with full capital pro-
tection, with coupons linked to interest rate indices (LIBOR, CMS, etc) and/or
to FX indices. Many bonds had initial fixed coupons ("teasers") and/or min-
imum global floor. The local market has started to develop in Greece since
2000 in tandem with international markets but a sudden event in the begin-
ning of 2007 stopped any dynamic for these bonds at least for the foreseeable
future. One allegedly mispriced private issue, launched by the Greek Repub-

lic, reached through local and international intermediaries a bunch of Greek pension funds and provoked a severe political turmoil [31]. Legal actions were pressed and even a special parliamentary committee was set up to investigate whether pension funds had bought SBs at high prices. After this event, pension funds have been victimized in public eyes as target of the unscrupulous and greedy financial markets and SBs have been considered as the weapons to reap them off. Due to bad publicity of the event, every SB sold in Greece irrespectively of its form, duration, price, risk profile and credit quality has been demonized as a potential source of huge and illegal profits enjoyed by sellers and issuers. Up to that point, pension funds had been allowed to invest freely their assets to any capital guaranteed bond issued by the state or by a bank domiciled in Greece. After this event, the law regulating investments of pension funds has changed, restricting this sort of investments to a mere 2%[3]. Contrary to the international practice [29], and although Greek pension funds have always been classified as professional investors[4], the new law in essence deprives pension funds from the benefits of investing in SBs. Retail investors are still allowed to invest in these bonds according to MIFID[5]. Although financial innovation helps investors in their hunt for risk-adjusted profits, helps markets to integrate, reduces costs and contributes to the reduction of the volatility of economic activity [32], its application especially to structured products (SBs is a subset of structured products, see section below) has been severely criticized. When things turn nasty for investors or for the economy in general, for reasons usually unrelated to structured products, politicians and the press blame implicitly financial innovation though accusations against these products for being too complex, incomprehensible and a source of losses. For instance, in Italy due to a fall in economic cycle and accounting manipulation, when municipalities started to show losses, the obvious culprit was the incomprehensible swaps [25]. Moreover, securitized products (mortgage-backed securities, CDO's, etc) were considered as responsible for the recent subprime crisis in US [61]. Finally, in Norway structured products were restricted to institutional investors when losses have started to emerge [51].

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[3]Greek law : 3586/No 151/ 10/07/2007.

[4]Greek law: 3606/No 195/17/08/07.

[5]MIFID:Markets in Financial Instruments Directive 2004/39/EC has been in force in Greece since November 2007.

This paper is organized as follows. Section 2 provides the various definitions of SBs, a comparative analysis of the legal frameworks in various countries and an extensive overview of the criticisms and supports concerning these products. Particular attention was paid to behavioural factors explaining investor's bias for these bonds. The section is concluded with an evaluation of whether developed criticisms are justified or not under the light of SBs' unique characteristics and existing market practice. In Section 3 there is a descriptive analysis of the global and Greek SB market. Section 4 analyses how SBs are valued in the presence of corresponding swaps and boundaries for prices are developed. The models used for the pricing of the particular classes of SBs are briefly mentioned. Valuations, results and analysis of the SBs for the Greek market exist in Section 5. Conclusions follow in Section 6.

2   Criticisms and Supports for the Structured Bond Market

2.1   SBs defined

SBs are falling within the broad and imprecise category of structured products. SEC, NASD and NYSE define a "structured product" as a *security derived from or based on another security (including a bond), basket of securities, index, commodities or foreign currency* [11]. This broad definition includes virtually any product in the market except "vanilla products" such as simple bonds with fixed or floating coupons, currencies, equities and commodities. It includes almost all derivative products, securitized products and credit products such as CMBS, RMBS, CDO, CDO^2, CDS, CLO, credit linked notes, commodity or FX-linked notes, CMS's, range accruals, (reverse) convertibles, etc. Structured products can have protected, partially protected or at risk the capital invested (a detailed overview of these products exists among others in [73] and [26]). Investors usually buy these products in a note format, unless they are allowed to have access to the underlying market the structured coupon is linked to and can invest directly in that market. It is worth mentioning that the above definition or definitions such as: *A structured bond is a cross between a traditional financial instrument and a derivative* [1] are implicitly based on

the traditional and controversial assumption that "vanilla products" have a predefined and well understood level of risk in contrast to structured products which are opaque with undisclosed or unforeseeable risks that cannot be easily assessed.

The fact that securitized bonds are falling into SB classification adds more confusion to the investment community especially when criticisms have to do with the opaqueness of the securitized products with the failure of the rating agencies to reflect the potential risks of various tranches in their rating assessments, and with their level of complexity that makes them inappropriate even for the sophisticated US insurance industry [60]. Spreads at issue for simple securitized bonds seem to systematically underweight the risk assumed by investors [36]. In structured credit markets, studies that have focused on the spread between equity and senior tranches conclude that information asymmetries between issuers and investors makes the latter choose the more senior tranches with spread that do not compensate them for the assumed risk [57, 39]. But these criticisms against risk mispricing do not justify the blame on securitized (structured) products for the subprime crisis [79] and the influence they have on the global economy [61]. In this paper, the securitization market is excluded altogether.

Among the questions posed about SBs are usually whether they are "fairly priced", whether investors are adequately presented for the associated risks this type of investment entails, whether the expected returns reflect the risks assumed by investors and whether this type of investment is suitable only to a particular class of investors or to the general public. Various authors in the finance literature have attempted to answer these questions. The range of answers and the diversity of approaches reveal not only how controversial this topic is, but also how anxious is the investment community to have definite answers. It is not unusual that in the battle for or against SBs participate not only natural stakeholders (issuers, arrangers, brokers, investors) but also regulators, academics and politicians. Many times heavy criticisms lie on the funding cost of the issuer which is hidden behind the structuring process and cannot be easily calculated as it has allegedly happened in the Lehman case [66]. On the other hand complexity is usually equated to excessive risk, something that is not necessarily true.

2.2   SBs and legal framework

The regulatory framework, although different in various part of the world, is primarily concerned with the protection of retail investors. Institutional investors are (or should be) responsible for the way they invest and must have all the means and resources to evaluate different investment choices. Investors' classification according to the level of sophistication (MIFID) or according to wealth level (accredited investors) entails different levels of protection towards structure products. And although US and UK acknowledge the importance of structure products in enhancing investor's return and their importance as a risk transfer mechanism, FSA regulation seems to weigh equally on the miss-selling risk by sellers and miss-buying risk by investors on the one hand and the opportunity cost suffered by investors who are restricted from structured products on the other hand. On the contrary, SEC approach weighs far more heavily on investor protection rather than on the opportunity cost of not investing in this type of products [11]. Sometimes, criticisms lie on the fact that sellers fail to perform the "reasonable-basis" test on the retail investors and they do not present *fair and balanced disclosures of the material aspects of the structured products* [54]. Interestingly enough, MIFID seems to be more in line with the FSA approach and focuses primarily on investors' classification. Possible remedies, like the enhancement of the definition of "accredited investors" to include not only the wealth level but also the sophistication level have been proposed in order to balance the cost of restricting access to these products versus the benefit to investor for whom such investments are valuable. Professional bodies try to standardize best selling practices in the market by issuing various guidelines that refer to the way presentations, promotions and marketing for structured products should be conducted[6]. France demands objective and balanced marketing of complex instruments with specific language used for product promotion if the target group is retail but it demands no protection for private or institutional investors[7]. It is clear that after the recent financial crisis sweeping changes in the financial industry have affected inevitably the structured product market not only on the regulatory but also

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[6]NASD Notices to Members: Structured Products:Principles for Managing the Distributor-Individual Investor Relationship, etc.

[7]Autorité de Marchés Financiers, Position No 2010-05-15 October 2010, Marketing of complex financial instruments.

on the operational level [74].

2.3   Empirical studies about the prices of SBs

Extensive empirical studies have dealt with the problem of whether structured products are "fairly" valued or not. Usually fairness is measured as a percentage price difference between the issue (or transacted) price and a theoretical model price or as a difference between the volatility used in the embedded option of the structured product and the volatility appeared in listed options of similar type and maturity. Sometimes it is measured as a spread between the actual coupon and the coupon the note should have in case pricing were based on a theoretical model with volatility implied from options directly observable in the market. Although results for price differences are usually reported with respect to specific products and markets, sometimes they are reported on a relative basis compared to other products.

In the Swiss Market, a market where structured products have been very actively and heavily traded for many years, Wasserfallen and Schenk in [78] by examining one year index-participation products with minimum and maximum guaranteed rate of return, found that there is no statistically significant overpricing in the primary and secondary market. Burth et al. in [20], by examining non-capital guaranteed products with concave profile (essentially a combination of an underlying asset and a short call option on the same asset) launched by various issuers in the same market, found a bias in favour of issuing institutions (around 1.91%) and recognized the importance of "teasing coupons" in order investors to be attracted *"even if these coupons add nothing to the pricing from a finance point of view"*. The authors could not distinguish what portion of the overpricing is attributed to hedging costs incurred by issuers, and what portion is attributed as a net profit. Similar results for the Swiss market were presented by Grünbilcher and Wohlwend in [42] who found that the embedded put options of the reverse convertibles(RCs)(a type of non-capital protected bond with concave pay-off) were priced significantly lower than the corresponding put options prices in EUREX, and in essence investors were selling cheap volatility through structured products. Wilkens et al. in [80], by examining non capital guaranteed RC and discount certificates (DCs) based on DAX and NEMAX indices with maturity up to 1.3 years

found mean overpricing of 7.46% for the DCs and 2.29% for the RCs, with the overpricing to be especially significant in the primary market. Similar results for the German market were reported by Stoimenov and Wilkens in [69] by examining notes with up to two year maturity. They found that issue price deviations are in the area of 2.07% and 2.67% for simple notes based on DAX and individual DAX stocks respectively and 2.69% and 4.77% for more complex notes. They also confirmed the "Carlin's result" [21] that "overpricing" is proportional to product complexity. Wilkens and Stoimenov in [81], by focusing on the "long" and "short" stock index certificates in German market with up to one year maturity, usually presented as forward contracts and not as barrier options as they should have been presented, found that there is around 4.5% deviation from the theoretical arbitrage-free price for "long" and 7.1% for "short" certificates in favour of the issuing institutions which also provided, through market making, liquidity in the market. The institutions, by employing semi-static super-hedging strategies had almost risk-free profits. Entrop et al. [34] showed that Open-end Leverage Certificates for retail investors in German market were priced ar least 5% above the theoretical values. This represented presumably the premium paid to access the particular market segment and the various hedging costs incurred by the issuing institutions. Depending on the behaviour of the underlying assets, SBs can be profitable for both the issuing institution and investors, and rising competition compresses considerably spreads. This was also confirmed by Bommel and Rossetto in [14], who reported price deviations between 0.51% and 1.01%. They have acknowledged the fact that issuing institutions and retail investors have different ways for evaluating products due to different degree of sophistication and market accessibility. Reverse exchangeable notes were also examined by Benet et al. in [7]. By analysing them in the US market, with maturity up to two years they found, due to discrepancies in volatility (implied or historical) used in the embedded put option of the notes compared to the volatility used in similar options traded directly in the option market, that mean coupon should be either 5.73% (based on implied volatilities) or 5.97% (based on historical volatilities) higher. The more volatile is the underlying stock or the more "riskier" is the issuing institution, the larger is the difference between actual and "fair" coupons. In Danish market, Jørgensen et al. in [47] found out overpricing to be in the area of 7% and particularly for bonds with maturities more than four

years to be around 9.79%. Especially for bonds with maturities twenty years mean overpricing was around 10%. Carlin in [21] found out that complexity is an important determinant of price formation for the preservation of high margins, especially in structured products. Increased complexity in the structuring process makes prices to stay above marginal costs *even* in the presence of many competing issuers and interestingly enough retail investors choose to be uninformed about competing prices due to their inability to understand these products. The phenomenon that issuers use sophisticated models (like the Heston stochastic volatility model, [41]) in order to price better the skew in barrier options for Bonus Certificates(BCs)(a form of non capital guaranteed with embedded barrier puts) has been studied for the German market by Baule and Tallau in [5] and [6]. They recorded overpricing ranging from 2.2% to 4.7% for structured notes with average maturity around 2.16 years. Moreover, they observed that overpricing is a decreasing function of the option moneyness and they confirmed the life-cycle hypothesis, i.e. that overpricing is a decreasing function of product's time to maturity. Life cycle hypothesis has also been confirmed by Baule in [3] based on DCs in German market. Order-flow hypothesis, i.e. when issuers by being market-makers in the structured notes, overprice/underprice them depending on the flow they anticipate, has also been confirmed. Nicolaus in [58], by studying BC and capped BC in German market, confirmed the significant improvement of the market so far as overpricing is concerned (in notes of almost five years to maturity with out-of-the-money embedded puts, overpricing was 7.46% in 2005 and only 2.8% in 2008). Improved liquidity and reduced overpricing have lowered barriers for retail investors. Branger and Breuer in [15], by examining DCs, BCs and Spring Certificates(SCs) with maturity up to two years in German market, found out that under the normative expected utility theory these products are optimal for retail investors with moderate risk aversion (CRRA utility function) but complicated structures (structures with path-dependent embedded options) are always suboptimal for them and they should even short them, if they can.

2.4   Behavioural Finance and SBs

For the explanation of investors' preferences to these products despite the "unfair" prices they pay (a phenomenon usually called "investors' irrationality", or "departure from the standard rational expectation theory"), behavioural

finance is employed. Cumulative Prospect Theory (CPT) [48, 75] is used in order to justify investors' irrationality when they opt for SBs. In general, CPT is used when standard normative expectation theory fails to explain human behaviour as in the case of investors' preference to sporting products over direct bets even with homogeneous expectations [18]. CPT suggests that utility functions usually employed in standard finance theory are not appropriate and instead S-shaped functions (convex in losses and concave in profits) should be used. Moreover, investors evaluate their anticipated profits and losses not indifferently to their level of wealth but instead they use some reference point when they evaluate potential outcomes. Behaving in a rather irrational way, they form in their minds fictitious (mental) accounts and they apply different investment rules to them [72]. For example, the usually high introductory fixed coupons ("teasers") of a SB are placed in a different mental account (apparently with a more conservative orientation) in investor's mind than the rest of the structured coupons. In this way investors do not value SB in its totality as they ought to do, since in their minds two different investments are formed. Mental accounts make investors frame unconsciously their choices. This psychological process makes them more happy and is usually referred as "hedonic framing". Another aspect of behavioural finance is that investors overweight low probability events (usually based on recent performance) and in this way value differently investment choices. In essence, when people evaluate risk, they transform objectively calculated probabilities, via a weighting function which overweights the tails of the distribution returns, into subjective estimations [2]. This is exacerbated when they cannot calculate or even estimate the true probabilities as in the case of complex SBs and as a result they usually overprice them. This phenomenon is called probability overweighting (or overestimation). Rieger in [62], by examining BCs on DJIA and SMI and worst-of-basket barrier DCs on S & P 500, DJ Euro Stoxx 50, Nikkei 225 and SMI found out that probability misestimation is the main source of investors' mispricing and pointed out the inability of investors to incorporate correlation into their pricing mechanism even when they had correctly predicted it for different stocks or indices. Investors' inability to correctly estimate probabilities makes them more prone to accept short dated (usually up to one year) SBs since they overestimate potential gains and to accept longer dated SBs only when they are capital protected by overestimating potential losses.

But unfortunately capital protected SBs seem to be a suboptimal choice [63]. Shefrin and Statman in [65] explained investors' preferences to covered calls (investors mentally separate option premium, dividends and stock price increase) and to some rather simple structured products by using behavioural finance tools such as prospect theory, mental accounts, hedonic framing and probability overweighting. In the US market, Edwards and Swidler in [33], by examining Equity Linked Certificates of Deposits (ELCDs), added marketing presentation to the factors affecting the preferences of investors, since ELCDs, despite the fact that they were advertised as producing equity-like returns, they performed less than US Treasuries and less than synthetic ELCDs, that on average had equity-like returns. Using similar arguments, Breuer and Perst in [17] explained the demand from retail investors for Discount RCs and RCs on DAX, something that again common utility theory failed to explain. Fischer in [37], by conducting a behavioural survey in the German investment community shed some light on how investors form decisions about investment in SBs. He mainly found out that investors, although their motives (diversification, hedging against risks and cost reducing) are consistent to the standard normative theory, they choose investment strategies that have conflicting objectives (such as betting and diversification) simultaneously. The role of financial advisor is mentioned as an important determinant of mitigation of investors' conflicting goals. By examining Multi Barrier Reverse Convertibles (MBRC) in the Swiss market and by finding an overpricing of $3.45\% - 6\%$ for products with maturities up to 1.5 years, something that corresponds to an average underpricing of the corresponding embedded short put by 29%, Wallmeier and Diethelm in [77] statistically attributed this to product complexity, to "teasers", and to the fact that overpricing is less profound when underlying stocks are more liquid. Again behavioural arguments were used to explain investor's preference to these products. Expected utility maximization framework failed to explain why retail investors chose the cost ineffective path-dependent locally-capped products on S & P 500 rather than the corresponding globally capped ones. Bernard and Boyle in [8], who founded an overpricing around 8% for locally-capped five year notes, attributed this to probability overweighting, to "Carlin's result", and to the fact that retail may chose not to be informed about product complexity but instead makes its choices randomly with the help of commission-based incentivized intermediaries. Chang et al. in [23],

by examining the structured product market in Hong-Kong prior to the credit crisis in 2007-2009 found out that retail investors who were "financially illiterate" in essence were "pulled" by product distributors irrespectively of the associated costs. On the contrary, financially literate investors were behaving in a more rational and consistent to the standard theory way and they were including less structured products in their portfolio. Hens and Rieger in [45], although acknowledge that in the simplified mean-variance world of Markowitz [53] there is no role for SBs (in fact there is no role for any derivative security since it exists only the market portfolio and the risk-free asset), they tried to classify SBs according to investors' utility function. They found that utility maximizers with strictly increasing and concave utility function should choose only SBs with convex pay-off and that SBs with concave pay-off are always suboptimal investments. This is in sharp contrast with the majority of existing SBs and the reasons for this departure from rationality can be explained with the usual behavioural arguments. Henderson and Pearson in [43], by focusing on products with maturity slightly longer that one year in the US market, they found overpricing around $7.7\% - 8.7\%$. They also found that US market is dominated by SBs with concave pay-off when linked to individual stocks and with convex pay-off when linked to indices. Suboptimal choices for SBs with concave pay-off and overpricing are again attributed to behavioural factors. Szymanowska et al. in [70], by analysing RCs of duration at most three years in the Dutch market, found out an overpricing at issue of around 6%, which was not model-specific since long-dated listed options where used for the put options embedded in the bonds. Only 23% of the overpricing could be explained by rational factors (trading volume, price of RCs, dividend yield, volatility and discount rate) and the rest was attributed to behavioural factors such as framing, representativeness bias and marketing. Behavioural studies by Vanini and Döbeli in [76] found that there is no gender difference when retail investor choose SBs and more importantly there is a difference between the stated and revealed preferences. Ofir and Wiener in [59] added to the usual explaining factors for investors' preferences to SBs *the disposition effect* (people avoid to realize losses and SBs, that contain mandatory conversion when a price cross a particular level, are not liquidated even when this particular level is approached), the *herd behaviour effect* (large number of people act in the same way at the same time), the *Ostrich effect* (people on the one

hand are willing to pay a premium for holding illiquid SBs and on the other they pretend that they do not hold them by focusing only on maturity date!), the *probability distortion effect* (people tend to erase from their minds rare events, so SBs that produced unfavoured results based on worst-case scenario are over-valued), and the *hindsight bias effect* (events that occurred in the past are perceived as more likely to happen in the future and in this way probability overestimation is formed). Henderson and Pearson in [44], by analysing the popular SPARQS bonds, a type of equity-linked non-capital guaranteed medium-term note traded in US exchanges, found that their returns do not covary with the investor's marginal utility and so they should not be selected under the normative portfolio theory (the expected returns for these bonds were lower than the risk free rate). They recorded a mean overpricing of 8.77% (and a maximum 23.49%) and again they resorted to prospect theory to explain the increased popularity of these bonds. Bernard et al. in [10] examined Index-linked notes from the issuers' point of view under a weak set of assumptions that make their results applicable on a wide range of SBs. They found that for capital guaranteed notes the optimal design from the issuer's point of view is independent of issuer's utility, and for notes that the capital is at risk, optimal design is utility dependent or it may not even exist. Moreover, optimal design for SBs can generate discontinuous pay-offs something that it is usually encountered in practice. Besides, by using CPT and rather simplifying assumptions for utility function (like piecewise linearity), Roger in [63] showed the counter-intuitive result that if the point of reference is the risk-free rate or the underlying asset value, then it is *never optimal* for the investor to invest in capital guaranteed notes. It may be indifferent for the issuer but it is suboptimal for investors despite the usual marketing arguments. Investors should invest directly in the underlying assets, if they can.

2.5   Are criticisms against SBs justified?

Criticisms against SBs are focused on the deviations of actual transacted prices from model theoretical prices when the bonds are issued or when (and if) they are traded in the secondary market. These criticisms omit the fact that usually investors (even professional ones) lack access to derivatives market (or to swap markets as it was the case for the Greek pension funds) and as a result the only way to be exposed to specific risks are through SBs. They also neglect the fact

that discrepancies between actual prices and model theoretical prices are not a phenomenon encountered exclusively to SBs but is a general characteristic of derivatives including simple exchange traded options. The main causes for this are different volatility and correlation estimations, different models used and different credit assessments. In practice questionable results are produced when the issuing organization tries to hedge out the structured coupons (especially when the bond is long-dated) according to the hedges dictated by the model[8]. For instance the hedging effectiveness for a twenty year steepener (a popular class of SB with coupon linked to the steepening of the curve, usually expressed as the difference between a long dated CMS and a short dated CMS) is at risk due to lack of liquidity of long dated CMS digital options. That is why banks calculate "hedging reserves" and add them on the model price. The bank that is hedging the coupon flows usually reserves for every year that the swap is "alive" a percentage of the theoretical price produced (expressed in basis points) and adds it to the theoretical price. If for instance a twenty year steepener has DV01 14.5 and hedging costs are assumed to be 30 bp per annum then around 2.9% is added on the theoretical price. Popular type of models like the Black & Scholes oversimplifies reality and more sophisticated models are extremely impractical [71]. Due to this fact, technical (or "model") reserves that reflect model imperfections, are calculated. For a twenty year steepener, due to the long maturity of the bond, technical reserves could reach as high as $3 - 4\%$. Technical reserves are kept aside and released proportionately should hedging terminates, although in practice sales people consider them as "loss", add them on the price of the bond and pass them on to the investors. Finally, since hedging is a dynamic process, the bank is obliged to hedge the various risks (delta, gamma, vega, correlation risks, etc.) according to the model, bearing the bid-offer spread of the hedging instruments. These costs are estimated and added on the price. It is clear that illiquid and long dated derivative instruments produce much larger bid-offer costs (for the 20 year EUR CMS-steepener, these costs could be around 4% of the price[9]). All models encompass a large degree of unreliability simply

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[8]When an issuer launches a SB and decides to swap the structured coupons, the two products (bond and swap) are completely independent from a legal standpoint and the terms and conditions of them may differ substantially.

[9]So the total costs -hedging, technical, and bid-offer-for a typical 20 year EUR CMS-steepener can reach more that 10%.

because modelling, regardless the degree of sophistication, simulates imperfectly the reality. This is aggravated especially for long dated complicated structures. When techniques like over-hedging (where hedging is performed at degree greater than dictated by the model) are used, several percentage points on the price are added as additional hedging costs. Finally, on this price, the bank adds its profit for the time and effort it devotes to the structuring process and for the capital allocated to the swap, in case it exists[10]. Due to recent crisis, additional capital requirements for couterparty credit risk [67] that may ultimately result in additional costs added on the price of the bond, may be implemented. A deeper look to criticisms against SBs reveals that the core arguments are not against them per se but against the embedded derivatives they contain. The "irrationality" level caused by the demand for these products is not higher than the "irrationality" level of an investor who buys a complex derivative even if this is the only way to be exposed to specific kind of risk. The controversy lies on the fact that with the wrapping of the derivatives in a bond format, from the one hand investors can short complex derivatives, something that otherwise would not have been possible (at least not without high margin requirements), and on the other hand issuers can benefit from low borrowing costs that they do not represent their true credit quality [4]. An investor should always investigate, apart from the offer price of the bond, the implied credit spread (a good proxy for this is the asset swap spread) that this price implies for the issuer in order to estimate if he is compensated enough for the credit risk he assumes by buying the bond. Only extremely risk averse investors with sufficiently distorted probabilities (investors who overweight extreme outcomes) should buy options. Theory suggests that rational investors should most of the times short put and calls [30]. A potential way to do this is through SBs. Theoretically in a complete market setting, derivatives have no place at all since they are replicable by hedging strategies in the underlying products. But markets are incomplete or even if they are complete discrete trading makes them incomplete [16]. Derivatives can complete the market, making the pricing unique and utility independent and they can constitute an integral path of investor's wealth enhancement [52]. Furthermore, they extinguish market imbalances and arbitrage opportunities in a quick and efficient manner. It seems natural for investors with restricted access to derivatives

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[10] *Directive 2006/48/EC, Directive 2006/49/EC.*

market either due to regulatory constraints, lack of sophistication or small size
to resort to SBs in order to overcome these shortcomings. Cocozza and Or-
lando in [24] proposed risk-adjusted criteria (RAROC and EVA) for choosing
a SB given a particular portfolio or for choosing a suitable asset portfolio given
a particular SB. Jessen and Jørgensen in [46], by assessing SBs in a portfolio
context, showed that investors with medium level of risk aversion (like pen-
sion funds) should include structured bonds in their portfolios provided that
they cannot access the underlying market, the underlying market is negatively
correlated to the s of the SBs and the associated costs do not wipe out the
benefits of diversification.

3   Descriptive Analysis of the Structured Bond Market

3.1   The Global SB Market

There has been a rampant development of the SB market. From 1999 until
2010 roughly 1,8 trillion EUR of SBs were issued globally[11]. After 2003 vol-
ume has been exploded. Starting from around 40 bln EUR in 2003 the total
volume in 2010 reached more than half a trillion. As it is shown in Figure 1,
the preferred currency has been EUR followed by USD. After a small pause
due to the financial crisis in 2008, the volume continued to increase and in 2010
there was a record issuance (0.571 trillion EUR) with the EUR-denominated
issues to reach around 300 bln. Global champion in the issuance was Germany
(Figure 2) that started from 3 bln EUR in 2000 and reached more than 340
bln EUR in 2010. In US, due to the fact that investors have a more equity-
friendly mentality and they invest mainly in stocks, SB issuance lags behind
Europe with volume around 110 bln EUR in 2010. Issuance in Germany and
US have dominated the global market with combined volume of around 32%
of the global volume in 2000 and more than 80% in 2010. Only in 2006, their
combined volume decreased to 25% of the global volume, a year where global

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[11]The data source used was Bloomberg L.L.P. because it is regarded among professionals
as the most comprehensive data source for this type of bonds. Volumes have been converted
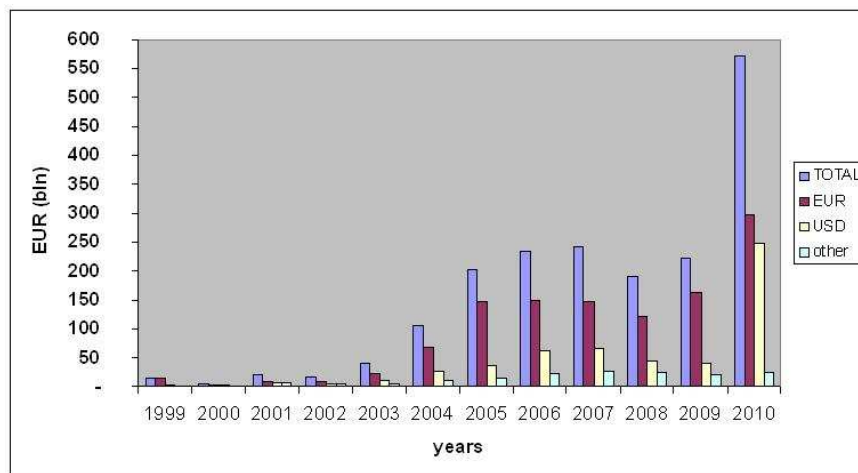in EUR with the appropriate exchange rate.

Figure 1: Structured Bonds Global Issuance

recovery increased risk appetite and issuance in other countries peaked considerably. In the last post-crisis years of 2009 and 2010, Germany's domination in the global issuance (55% in 2009 and 59% in 2010) reflects the better shape of its economy compared to the global one, with side effect the abstention from the regulatory frenzy against "non-vanilla" products that captured the rest of the world. In any case, despite the introduction of regulatory constraints aiming to curb derivatives trading primarily in the US market [22], American issuance in 2010 represented around 20% of the global issuance, peaking from 10% in 2008 and 8% in 2009. Regarding the maturity of the bonds in various currencies, five to ten years maturities dominated EUR issues (around 40%), reflecting medium term financial objectives (Figure 3). Issues with maturities up to three years represented more than 30% of the USD issuance. More balanced distribution appears in GBP issues. CHF issuance was confined to maturities less than a year for tax reasons. The majority of SBs with maturities more than twenty years were either Tier I or subordinated notes issued by banks for capital enhancement. Apart from GBP issues (more than 30%) and NOK issues (around 25%), the bulk of the issuances in other currencies was in maturities up to twenty years. Another point of remark is the issue price of SBs. Figure 4 shows that from around 32,000 issues in EUR, 85% were price at par. The rest of the issues was either discounted securities (with no
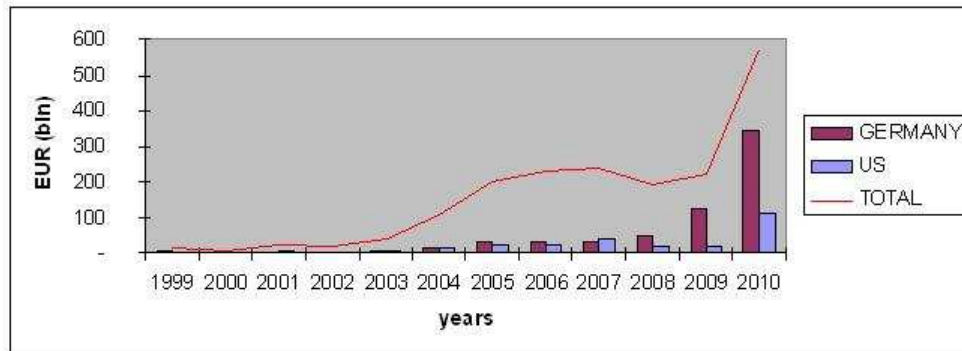
Figure 2: Germany and US Structured Bonds Issuance

YTM CCY	YTM<=1	1<YTM<=3	3<YTM<=5	5<YTM<=7	7<YTM<=10	10<YTM<=20	<20<YTM<=50	YTM>50
EUR	12,7%	8,5%	17,5%	18,8%	21,4%	15,1%	3,1%	2,9%
USD	4,70%	26,52%	16,04%	10,80%	20,32%	16,08%	4,31%	1,24%
GBP	1,16%	4,94%	19,78%	18,04%	6,00%	16,58%	17,66%	15,84%
CHF	45,17%	12,31%	12,57%	5,66%	7,35%	16,08%	0,04%	0,81%
JPY	4,03%	5,43%	13,94%	7,57%	18,55%	33,59%	9,42%	7,47%
SEK	0,00%	20,44%	52,48%	10,52%	14,58%	1,42%	0,00%	0,57%
DKK	1,30%	43,06%	23,45%	6,18%	16,27%	8,74%	0,00%	1,00%
NOK	0,00%	13,57%	14,59%	6,84%	29,27%	10,82%	4,08%	20,82%
CAD	0,02%	3,59%	18,41%	14,10%	31,79%	19,24%	8,06%	4,80%
AUD	0,32%	25,49%	10,56%	9,31%	37,74%	7,65%	2,21%	6,72%
HKD	0,00%	50,71%	36,95%	10,73%	1,61%	0,00%	0,00%	0,00%
NZD	0,00%	0,48%	3,47%	32,39%	36,54%	17,93%	0,00%	9,19%

YTM=Year To Maturity/CCY=Currency

Figure 3: Issuance per duration and currency

interim coupons) or bonds issued below par that accrue to par at maturity in case they are capital-protected. The corresponding figures for USD and GBP issues were around 92%.

3.2   The Greek SB Market

Greek market has been analysed since its inception in 1999 up until 2010[12]. As it happens to all peripheral markets, the market has been developed with a time lag to the European and to the US market. Issuers were mainly Greek

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[12]Since then, due to Greek debt crisis, capital markets have been frozen for local issuers and the state altogether.

Percentage of issues priced @ 100		
	Total issues	Issues priced @ 100	(%)
EUR	32.722	27.798	84,95%
USD	30.176	27.549	91,29%
GBP	1.745	1.600	91,69%
CHF	1.777	1.741	97,97%
JPY	1.766	1.594	90,26%
SEK	357	215	60,22%
DKK	43	19	44,19%
NOK	120	119	99,17%
CAD	918	892	97,17%
AUD	438	424	96,80%
HKD	12	12	100,00%
NZD	13	13	100,00%
TOTAL	70.087	61.976	88,43%

Figure 4: Issues per currency priced at par

Republic and major local banks[13]. In total, Greek Republic issued 2.34 bln
EUR in 11 issues. One of them, issued in 1999 was denominated in DM
and the rest, until 2007, were denominated in EUR. Banks issued in total
5.715 bln EUR with issuer champions EFG and Alpha. EFG issued 2.467 bln
in 124 issues and Alpha issued 1.244 bln EUR in 50 issues. Almost all the
issues were senior and they were executed through EMTN (European Medium
Term Note) programs something that shows that SBs were an established tool
for the enhancement of local banks' liquidity [35]. The majority of bank's
issuances was in EUR (79%) and around 10% were in USD and GBP. Most
of these were conducted privately with no active secondary market. Investors
who bought these issues were mainly funds, pension funds, banks and retail
investors. More than 95% of the amount issued was capital guaranteed with
mild structuring on the coupons and a risk-averse orientation. In contrast

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[13]The major local banks, active in SB markets, were : EFG Eurobank Ergasias
S.A.(EFG), Alpha Bank S.A.(Alpha), National Bank of Greece S.A.(NBG) and Emporiki
Bank S.A.(EMP)

to SBs launched in international markets, in Greece, presumably due to lack of investment mentality and to the relative recent introduction of derivative market (since 2000), investors have preferred "safer" structures with minimum guaranteed rate of return, existence of fixed coupons or coupon floors and capital protection. Usually, bonds with medium and long maturities (more than five years) had links to interest rate indices. FX-linked bonds had usually shorter maturities. SBs linked to equity indices, to basket of stocks or to the performance of funds were sporadic with negligible issued amounts.

SB issued by the Greek Republic and banks are classified according to the type of structured coupon they have. The major types are listed below:

- Range Accruals
- Snowballs
- Complex SBs
      Snowball Range Accruals
      Target Redemption
      Autocallables
      Wedding Cakes
      Cross Currencies SBs
- Curve structures
      Steepeners
      Switchable with global floor
- Simple SBs

Simple structures have fixed or floating coupons (or a mixture of them) and/or some sort of coupon restriction (for instance existence of minimum or maximum). Curve structures have coupons linked to steepening, flattening or to a particular shape of the curve. Reference curves were usually the European and the US swap curves. In range accruals, coupons accrue within (or outside) a range of a specific index and in snowballs current coupon depends (additively, multiplicatively or in some other way) on previous coupons [13, 50]. Complex structures either combine characteristics of simpler structures (for instance range accrual snowball or range accrual target redemption) or have entirely new features (autocallables, etc.). Figure 5 shows the share of each particular type for banks. Banks issuance was dominated by curve structures (34%) followed by simple structures (29%). Complex structures were only 6% of the total issuance. Most of the issue prices (97%) were priced at par but issue

prices as low as 77.5% were observed. Issues (126 in total) representing 72.48% of the volume were callable. Surprisingly, only 67 issues representing 31.2% of the volume had introductory "teasers" with average coupon 6.1% (much higher than prevailing average one year rates for the years 2000 until 2008). Average fixed period was 1.23 years or 14% of the average maturity. That means that only in around 15% of the coupon periods were the coupons fixed.
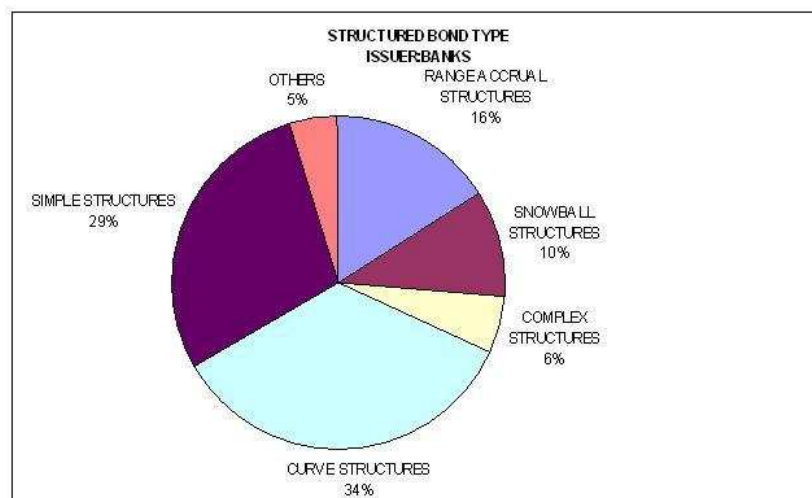

Figure 5: Local Banks

Banks also issued structured Tier I (most of them were callable perpetuals) or subordinated SBs for capital enhancement. Around 2.34 bln EUR were issued, with champion issuer the largest local bank, NBG, with share of more that 45% in this market segment. These bonds (as it is shown later) were an extremely cheap source of capital for the banks because the structuring process managed to hide effectively the implied cost of funding to levels disproportional to the credit risks undertaken by investors. These issues were invariably issued at par. Greek Republic had focused on SBs linked to interest rates. More that 60% of the amount issued was related implicitly or explicitly to steepening of the EUR curve as it is shown in Figure 6. There was a cross-currency issue representing 5.56% of the issuance volume. It is worth noting that complicated SBs like callable switchable (to simple floating bond) curve structures were not uncommon in order to ensure cheap funding. Invariably all SBs issued by the
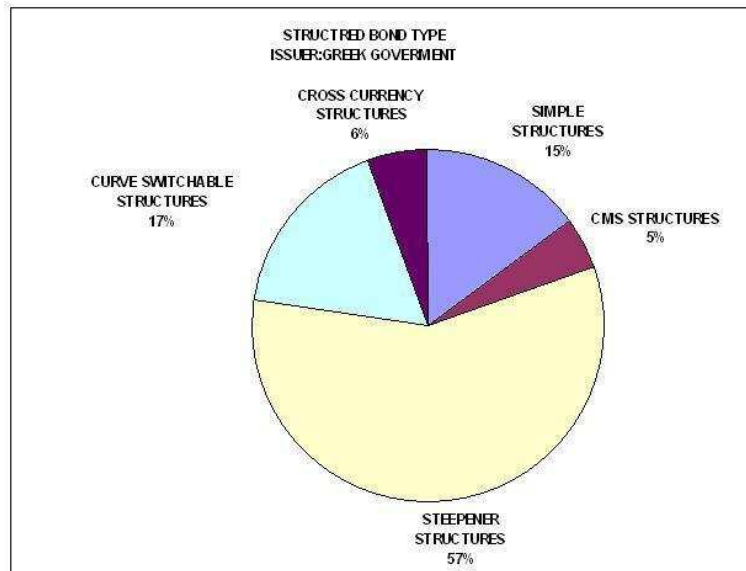
Figure 6: Greek Rebublic

Greek Republic had issue price equal to par. Most of the issues were prepared through the method of "reverse inquiry" (In a reverse inquiry method there is a request by investors to the issuer, either directly or through intermediaries, for a security with specific characteristics). Greek Public Debt Management Agency (GPDMA) was presumably approached by some primary dealers - an officially appointed set of banks that provides liquidity through market-making operations on Greek debt - who played the role of the arranger. GPDMA in cooperation with the arrangers priced the issues and arrangers sold the bonds to their customers. The bonds had no restricting clauses regarding the type of investors that could invest in them. Most of them were sold to local investors (retail and institutional). It is not known whether GPDMA entered into a swap for all the issues, although it is well known fact that for some of them a swap with the arranger was executed so that the coupon risk of the bonds can be offloaded. This is not an unusual practice for the states since swaps enables them to have payments usually linked to one year EURIBOR which is the benchmark index for annual budgeting.

4 SB Valuation

4.1 SBs and Swaps

In this section it is shown how SBs are valued. Exposition is kept simple because the primary objective is to show that investors and issuers value SBs in a different way that depends on the level of sophistication, on the ability to access the derivatives market, on the different hedging strategies they employ and on the level of risk they want to bear. Although in theory the pricing of a SB does not present any peculiarity, in practice, different risk assessments, restrictions to access particular markets related to coupon performance, inability to dynamically replicate pay-off and asymmetry of information make pricing more complicated and not unique for all the various parties participating in the transaction. Small-sized, private complex structures without active secondary market aggravate the situation. In practice, the notion of "fair price", which is very often considered in the finance literature as unique, becomes very subjective and represents different things to different people. From a theoretical standpoint, the price of a SB equals the expected discounted (adjusted for issuer's credit) cash-flows, where the expectation operator is under an appropriate risk-neutral measure. The curve used for discounting and the curve for projecting the structured coupons, in case they are linked to interest rates, may differ. Forward measures, depending on the choice of a particular model, are used for pricing.

It is assumed that an issuer launches a SB with notional amount of 100. The bond matures at time T and has a vector of structured coupons $\widetilde{SC}^{14}$. Some of the components of the vector may be zero. The vector may contain some fixed elements, usually in the first coupon periods, which are usually larger than the corresponding prevailing interest rates, in order to "tease" investors, with limited degree of sophistication or with needs for front-loaded income or simply for tax purposes, to buy the bonds. M denotes the redemption price per 100 nominal value payable at maturity T or before subject to fulfilment of some conditions (as in the case of Target Redemption Notes). Usually the redemption amount M equals to 100 (par) but it can vary, or be at stake subject to suitable conditions. Callable (or auto callable) and putable characteristics can be incorporated. In case the issuer has a liquid credit curve, the investor

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[14] the symbol $\sim$ denotes a random variable or a random process.

should use this curve for discounting the projected cash-flows. In practice this is not always the case. In most cases the investor uses a benchmark curve (usually a government one) and adds a uniform spread to this curve for the riskiness of the issuer. The choice of the curve used is subjective and depends on investor's perception about risk. It also depends on the access he has to instruments used for the construction of this curve. The above methodology is not confined only to SB valuation but to any bond valuation [35]. For instance, retail investors usually compare corporate issues with the corresponding government ones which they consider safer. Domestic institutional investors usually compare their investment choices with benchmarks they have either by regulatory constraints or by subjective beliefs. Alternatively, the investor could add a vector of spreads to the curve, reflecting the credit riskiness of the issuer for each period until bond's maturity. In this way a shifted curve is used for discounting. If an institutional investor is restricted to invest only in bonds issued by specific issuers (until recently that was the case for the Greek pension funds) or by issuers with a specific credit quality, the curve for comparing investments should be constructed from the bonds of this particular segment. In case investor has access to the swap market, the benchmark curve used is usually the so called swap curve which is built using the most liquid interest rate futures, FRAs and swaps. It is denoted by $PV(t, \widetilde{X}, s, \mathcal{C})$ the expected discount value at time t of a stream of uncertain cash-flows $\widetilde{X}$, where in the valuation model the curve used is denoted by $\mathcal{C}$ and the corresponding credit spread by s. PV is a smooth function of s. The price of the bond at time t with spread s and curve used $\mathcal{C}$ is denoted by $P(t, s, \mathcal{C})$. The symbol PV includes the expectation operator under the corresponding measure that depends on the model used. This simplification is done because the model chosen for valuing SBs is not relevant for this section. The curve used by investor is denoted by $\mathcal{C}_1$ and the spread he attaches to the issuer by s. At the time of the issue $(t = 0)$, the value of the bond, as seen by the investor, is:

$$P(0, s, \mathcal{C}_1) = PV(0, \widetilde{SC}, s, \mathcal{C}_1) + PV(0, M, s, \mathcal{C}_1) \qquad (1)$$

Suppose that the issuer wants to swap the structured coupons $\widetilde{SC}$ to simpler payments linked to LIBOR[15]. There are various reasons why the issuer

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[15]LIBOR stands for London Interbank Offered Rate. In Euro area EURIBORs are used instead.

might want to do that with the prevailing one the uncertainty for the future structured coupon payments. The swap counterparty which is usually the arranger of the issue attaches to the issuer a spread s_1 which does not necessarily corresponds with the spread s the investor attaches to the bond. The main reason for this discrepancy, apart from differences in credit assessments, has to do with the fact that usually swaps are executed under ISDA and CSA [27] and in this way counterparty risks are mitigated through collaterization and regular mark-to-market. Moreover, a swap when only exchange of payments takes place, has smaller credit exposure that a bond which is fully funded. In case the issuer has better credit quality than the swap counterparty (usually a AA bank) the spread attached to the issuer by the counterparty is negative. The curve used for discounting the cash flows is the LIBOR curve which is denoted by $\mathcal{C}_L$. The issuer agrees with the counterparty to receive the structured coupons and to pay LIBOR plus the spread s_1. In this way issuer pays the structured coupons to the investor and he's left only with the LIBOR payments to the arranger. Usually the rates chosen have maturities and frequencies that match those of structured coupons but this may not always be the case. For instance, if structured coupons are paid annually it is the one year LIBOR paid every year. Nothing could stop of course the arrangement in the swap to be for a 6 month LIBOR paid every 3 months (detailed exposition about swap valuation and curve construction exists among others in [56] and [38]). The value of the swap between issuer and the swap couterparty at time t with spread s calculated over the curve $\mathcal{C}$ is denoted by $\mathrm{swap}(t, s, \mathcal{C})$. Its value, at issue time $(t = 0)$, as seen by the issuer is :

$$\mathrm{swap}(0, s_1, \mathcal{C}_L) = PV(0, \widetilde{SC}, 0, \mathcal{C}_L) - PV[0, M * (\widetilde{L} + s_1 * \widetilde{1}), 0, \mathcal{C}_L] \quad (2)$$

where $\widetilde{L}$ is the vector of LIBOR rates and $\widetilde{1}$ is the corresponding vector of ones. For instance if the issuer pays every year one year LIBOR and is attached a spread of 50 bp for a 10 year swap, then the $\widetilde{L}$ is an array of 10 elements representing the one year LIBOR payable every year and $s_1 = 0.5\%$. Usually only the first LIBOR is known with certainty since it is fixed at $t = 0$ and the rest LIBORs need to be estimated based on the chosen valuation model. In equation (2) the discounting is performed by using the swap curve and any spread paid by the issuer is discounted using this curve. This happens because the swap curve is accessed by the swap counterparty which is usually

a bank that can hedge out the risks from the structured swap[16]. Due to the additivity of the function PV and the fact that a Floating Rate Bond with LIBOR payments when it is evaluated with zero spread on the swap curve is equal to par (more details exist in [19]) equation (2) can be written as:

$$\begin{aligned} \text{swap}(0, s_1, \mathcal{C}_L) &= PV(0, \widetilde{SC}, 0, \mathcal{C}_L) - [M - PV(0, M, 0, \mathcal{C}_L) \\ &+ s_1 * PV(0, M * \widetilde{1}, 0, \mathcal{C}_L)] \end{aligned} \quad (3)$$

The last term in (3) is the present value of the spread s_1. From equations (1) and (3) it is seen that the way investors evaluate the bond and the way issuers and arrangers evaluate the corresponding swap differ substantially. First, curves and spreads used may differ according to the perceived creditworthiness of the issuer and the access of the participants in the swap market. Second, differences may be attributed to the model used. The PV function encompasses the model used which is usually different for investors and swap counterparties.

By combining equations (1),(2) and (3) the value of the SB as seen by the issuer becomes:

$$P(0, 0, \mathcal{C}_L) = \text{swap}(0, s_1, \mathcal{C}_L) + M + s_1 * PV(0, M * \widetilde{1}, 0, \mathcal{C}_L) \quad (4)$$

For positive spreads attached to the issuer by the swap counterparty $(s_1 \geq 0)$ it holds that: $P(0, 0, \mathcal{C}_L) \geq \text{swap}(0, s_1, \mathcal{C}_L) + M$. For negative spreads $(s_1 \leq 0)$ and taking into consideration that the value of the swap ie negative (for reasons developed in Section 2.5) it holds that $P(0, 0, \mathcal{C}_L) \leq M$. Since $P(t, s, \mathcal{C})$ is a smooth function of s, by using Taylor approximation around 0 and ignoring larger than second order terms, equation (1) becomes:

$$\begin{aligned} P(0, s, \mathcal{C}_1) &\cong PV(0, \widetilde{SC}, 0, \mathcal{C}_1) + PV(0, M, 0, \mathcal{C}_1) \\ &+ s * \frac{\partial P(0, \widetilde{SC}, x, \mathcal{C}_1)}{\partial x}\Big|_{x=0} + \frac{1}{2}s^2 * \frac{\partial^2 P(0, \widetilde{SC}, x, \mathcal{C}_1)}{\partial x^2}\Big|_{x=0} \end{aligned} \quad (5)$$

When the same curves $(\mathcal{C}_1 = \mathcal{C}_L)$ and the same valuation models are used, by combining equations (3) and (5) the value of SB as seen by the investor

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[16]After Lehman's collapse in 2008 and the subsequent financial turmoil, EONIA curve instead of LIBOR one has been used for discounting in swaps due to large discrepancies between LIBOR and EONIA rates.

becomes:

$$P(0, s, \mathcal{C}_L) \cong \text{swap}(0, s_1, \mathcal{C}_L) + M + s_1 * PV(0, M * \widetilde{1}, 0, \mathcal{C}_L)$$
$$+ \quad s * \frac{\partial P(0, \widetilde{SC}, x, \mathcal{C}_L)}{\partial x}\Big|_{x=0} + \frac{1}{2}s^2 * \frac{\partial^2 P(0, \widetilde{SC}, x, \mathcal{C}_L)}{\partial x^2}\Big|_{x=0} \quad (6)$$

The fourth and the fifth term of equation (6) are the first and second order bond spread sensitivities and are denoted by Dur and Conv respectively. The first order spread sensitivity is ususally negative and the second order usually positive. Although the above equation requires the investor to know the value of the swap and the spread the swap counterparty attaches to the issuer, it is useful for providing boundaries for the price he should theoretically pay. For positive spreads ($s_1 \geq 0, s \geq 0$), an upper bound for the price of the bond is:

$$M + s_1 * PV(0, M * \widetilde{1}, 0, \mathcal{C}_L) + \frac{1}{2}s^2 * \text{Conv}$$

and a lower bound is

$$\text{swap}(0, s_1, \mathcal{C}_L) + (1 + s_1) * M + s * \text{Dur}$$

In case $s \leq 0$ and $s_1 \geq 0$ a simple lower bound is $\text{swap}(0, s_1, \mathcal{C}_L) + (1 + s_1) * M$. This provides a "floor" to the price of the bond as seen by the investor. Similarly it can be shown that for negative spread $s_1 \leq 0$ and for reasonably small positive spread s an upper bound of the price is M. It is clear the swap counterparty and the issuer are interested in the swap transaction they enter. Additionally, issuer is interested in the bond he sells mainly for reputational and regulatory reasons. On the other hand, investor is only interested in the bond he buys. Finally, under the above simplified assumptions the value of the bond can be connected with the value of the swap although this should concern only investors who can access the swap market.

4.2   What is the "fair" price that investors should "buy" SBs?

In theory every participant must make his own assessments before buying or selling SBs. Prices are dictated by demand and supply with negotiations between investors, issuers and arrangers being the usual way for shaping prices

in the market. It has been shown that a ceiling price the investor should pay is the redemption price M only when $s_1 \leq 0$ and s is relative small and positive. Moreover, it is clear from equation (4) that prices below model prices, although welcomed by investors, would result in losses for the issuer unless the swap had a positive value for him and of course negative value for the swap counterparty. In practice for issuers with better credit quality than swap counterparties, a ceiling for the price an investor should pay is the redemption price. Transacted price, in order not to be to the investor's detriment should be somewhere between the model price and the redemption price. This is why in practice, usually the price offered to the investors is the redemption price which in case of the primary market is the issue price of the bond. This price is written on the bond prospectus and is usually the indicative recommended price that an investor should buy the bond. The distance between the model price P and the issue price M is refined by competition and best market practices. Since in theory the model price P is known to the issuer and the swap counterparty (but not to the investor), internal policies of the issuer provide maximum permitted deviations depending on the particular characteristics of the structure. Similar principles must apply to the swap counterparty, which in the majority of the cases, is a bank. Apparently for long dated volatile structure (like long dated SBs linked to equity indices) the deviation can be substantial[17]. Naturally the swap couterparty incorporates in the swap price all the reserves and hedging requirements developed in Subsection 2.5. On the other hand the issuer cannot have these limitations and in theory he should calculate higher theoretical price. Furthermore, since high theoretical price entails high issue price under the convention of constant or near constant distance between theoretical and issue prices according to the particular type and duration of a SB, it is a matter of negotiation between the issuer and investors (or arrangers) the issue price of SB. In this sense, that is a "fair" price for an investor. Discrepancies between issue price and transacted price may exist but are usually small. Very often arrangers buy the bonds at re-offer price and distribute them to investors at issue price. Re-offer prices are at discount to the issue price in order arrangers to be incentivized to sell the bonds. Sometimes due to competition, this discount is passed on to the investors and arrangers receive a commission for the placement of the issue.

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[17]This is the reason why most state issuers, including Greece, avoid this type of SBs.

4.3   Models used for Valuation

In this section, the classes of models used for valuing SBs[18] are briefly mentioned. For SBs with coupons linked to interest rate indices (CMS, LIBOR, etc.) the major class of models used is the LIBOR Market Model class (LMM) calibrated with volatilities from ATM and OTM swaptions and caps/floors [40]. Another class of models used is the two factor Hull & White (H & W) class [19]. These are the most widely used models in the industry and they are considered standard among banks for interest rate structures. For SBs with coupons linked to FX indices, popular models are the Heston model with stochastic volatilities [41] or a B & S model again calibrated using appropriate ATM and OTM FX options. For bonds which combine FX-linked indices and interest rate indices or for cross currency bonds, a cross currency version of the LMM or of the H & W model with one or two factors is used with correlations between the stochastic factors calculated from historical market data.

5   Valuation and Results

As argued in Section 4.2, issue price indicates the price the issuer *is willing* to offer bonds in the primary market. Consistent with the literature, underpricing/overpricing (PDIFF) is defined as the difference between model price and issue price expressed as a percentage of the issue price. That is :

$$PDIFF = \frac{P_m - P_i}{P_i} \qquad (7)$$

where P_m is the model price and P_i is the issue price. Negative values of PDIFF show that issue prices are larger than model prices and positive values show that issuer sells the bond at a price lower less than the model price. For being consistent with the terminology used in the literature, the first case is referred to as overpricing and the second one as underpricing. This is prima facie misleading because it implies that model prices reflect the price the bond should be sold, where, as explained in the previous section, in reality a model price is the price the bond should have been transacted under a very strict set of assumptions.

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[18]Software by Numerix L.L.C. has been used for developing all the models used in this paper.

5.1   The Greek Republic

They were ten EUR denominated issues launched by the Greek Republic. For valuing these bonds, the spread that Greece was borrowing at issue date over the swap curve for time equal to the duration of SB was calculated ("the fair spread"). This spread was an input to the valuation model. Figure 7 shows PDIFFs expressed in bp per year. Overpricing ranges from 22 bp. to around
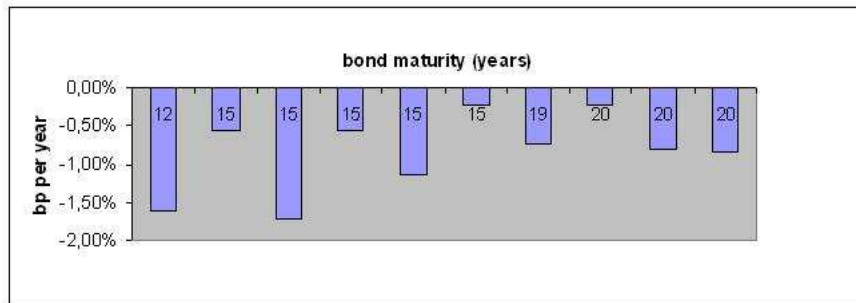

Figure 7: Greek Rebublic -price deviation

171 bp with mean notional-weighted overpricing of 92.6 bp. This is less than the average overpricing of 314.6 bp reported for international markets (Table 4). Moreover by finding the implied cost of funding that is consistent with price equal to the issue, Figure 8 shows that Greek Republic must have reduced its cost of funding on average by 81.13 bp per annum. Although fair spreads have
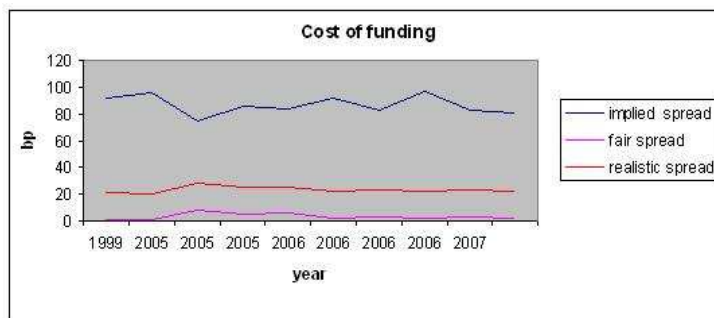

Figure 8: Greek Rebublic - positive funding gap

been calculated as the difference between Greek yields and the European swaps

at time of issue, in practice they were understated by around 10 bp for issues with maturity up to 10 years and by 20 bp for longer dated maturities because most of the times "on the run issues" were demanded at discount compared with the existing off the run issues. So "realistic fair spreads" were higher than "fair spreads". The mean realistic spread was around 23 bp. Thus, Greek Republic must have reduced its cost of funding on average by 60 bp per annum due to the issuance of SBs. Another interesting point is that there were price discrepancies between different models (LMM model with stochastic volatility and two factor H & W, both calibrated with volatilities of ATM and OTM swaptions and cap/floors). Figure 9 shows the various model price differences for the issues of the Greek Republic. Although the results produced have not revealed any systematic modelling discrepancy relative to bond duration they imply that prices for long-dated bonds depend very much on the model used and in case of these SBs price discrepancies can be as high as 13%.
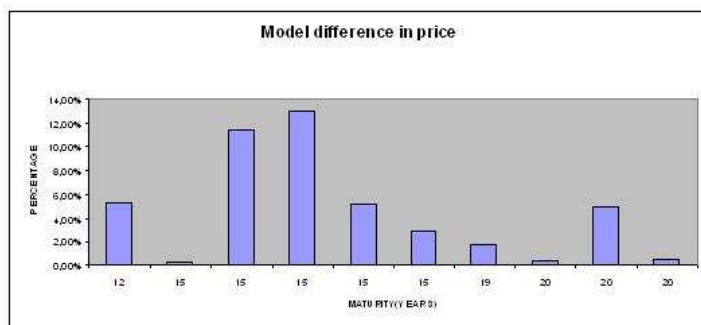

Figure 9: Greek Rebublic-model difference

5.2   Greek Banks

Perpetuals and subordinated SBs issued by local banks have been examined. These bonds were used as a tool for extremely cheap source of capital. Figure 10 shows that in 2005 the implied by these issues cost of capital for the Greek banks were negative (-11.85 bp per year) suggesting strong overpricing in favour of the issuers. In 2008 there was a relevant normalization of the cost around 168 bp although the average European Tier I spread for non-structured perpetual issues was at least 1.5 times higher. Since 2009 and onwards, markets
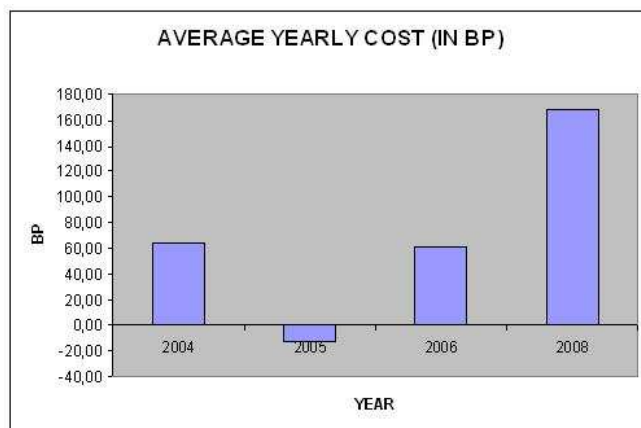
Figure 10: Cost of Capital-Banks

have been closed for local lenders due to the Greek debt crisis. Concerning the eight issues with total amount 2.6 bln the implied cost of capital were on average 26 bp per year. This was an attractive alternative compared to the more expensive option of capital increase or of the issuance of normal perpetuals with average spread of around 300 bp.

The bulk of senior SBs issues (84% out of 180 issues in total) launched by local banks were valued. Issues, that represent less that 8% of the total issuance amount (issues with no available information, equity-linked issues, or inflation-linked issues) were excluded. Figure 11 shows the frequency distribution of the price differences for the senior SBs valued. Pricing differences are wide enough and most of the issues are overpriced. Nevertheless, only a small percentage (14.28%) is underpriced indicating that the issue price that investors paid was less than the theoretical value. Price differences per maturity bucket appear in Figure 12. Overpricing was on average 64 bp per year. The smallest overpricing appeared in 7 to 10 years (51 bp) and the largest one appeared in the maturities of 10 to 25 years (81 bp). Long-dated bonds issued by banks and by the Greek Republic have in general the same main characteristics (duration, capital protection and "teasers") and the same magnitude of overpricing (77 versus 92.6 bp), taking into consideration that for the years 2000 until 2008 the average spread of these banks over the Greek Republic was not more than 16 bp. Surprisingly, strong overpricing exists for bonds with maturities up
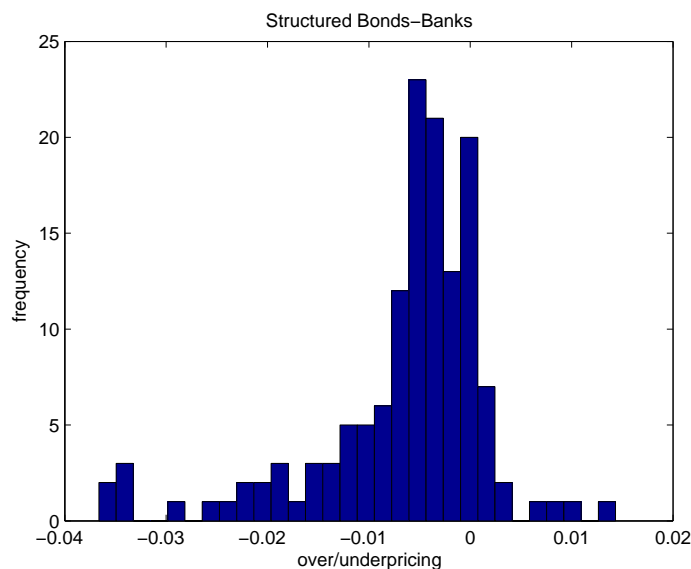
Figure 11: Relative price difference-Banks

to three years (71 bp) where the bulk of the issuance exists (more than 30%, duration weighted). For maturities of three to seven years overpricing is $57-59$ bp. Figure 13 shows that overpricing started in 2003 around 16 bp, peaked up in 2006 to 230 bp and from then on has started to decline reaching even underpricing levels in 2009 when markets turned prohibitively expensive for Greek issuers. It is clear now that senior SBs were a source of cheap funding for Greek issuers (including the Republic). On the other hand the average overpricing was milder than the overpricing occurred in international markets as it has been reported in the literature.

5.3   Empirical results

One distinct feature of the Greek SB market has been the absence of active secondary market and because of this the usual life cycle hypothesis cannot be tested. Most of them were capital guaranteed. Callable characteristics and "teasers" were not uncommon. SBs have been categorized into groups (Table 1) in order to test statistically the significance of price differences within groups and between groups. The analysis is based on PDIFF. Within each group the
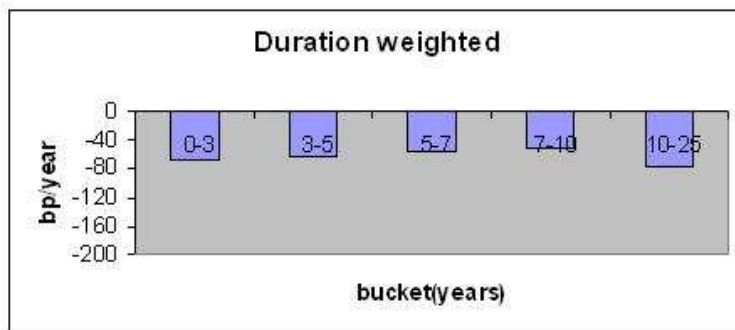
Figure 12: Senior Structured Bonds-Banks I

number of bonds (n), the standard deviation (stdv), the mean absolute deviation (MAD) and the InterQuantile Range (IQR) of the price difference are calculated[19]. In case normality is assumed a t-test is used for the significance of the results. Moreover, since the distribution of the price differences is unknown a-priori, the Wilcoxon-signed-rank test is used. For each group the Root Mean Squared Error (RMSE) is calculated with low values to denote small discrepancies between model and issues prices and large values to show either the opposite or instability. Results for the groups are presented in Table 2. It is clear that for all groups, average price differences are statistically significant with the exception of non-callable bonds issued by Alpha and simple SBs. The largest overpricing (135 bp) appears in non-callable bonds issued by EFG followed by curve structures (125 bp). The standard deviations within these groups are 1.46% and 1.25% respectively. Complicated structures with mean overpricing of 84 bp are not at the top of the list, something that at least questions empirically "Carlin's result". The mean overpricing of Range Accrual group is 81 bp and surprisingly the mean overpricing of the snowball group, despite its higher risk compared to other groups, was only 11 bp. This may be explained by the popularity of this type of SBs among local investors. SBs issued by the Greek Republic and by local banks seem to have

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[19]IQR computes the difference between the 75th and the 25th, and is a robust estimator of the spread of the data since extremes are left outside the calculation.
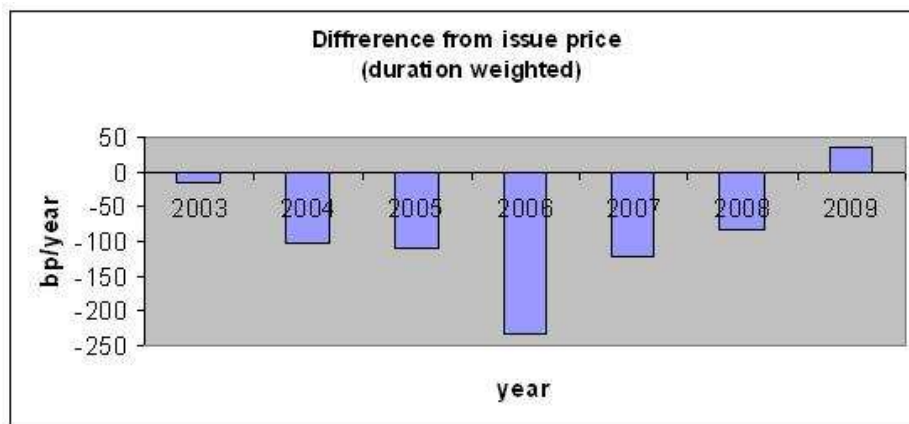
Figure 13: Senior Structured Bonds-Banks II

dispersed price differences (IQR for the two groups is 59.2 bp and 68.8 bp respectively). For bonds with "teasers" the Average Fixed Coupon (AVFC) is calculated over the whole duration of the bond. Figure 14 shows the histogram of PDIFF/AVFC. Overpricing is mitigated when fixed coupon are taken into account and 79.1% of the issues have been overpriced less than AVFC. To test price differences between callable and non-callable SBs and between SBs with and without "teasers" a non-parametric Mann/Whitney test is conducted. Results appear in Table 3. Only 20% of the issues with "teasers" are underpriced. Contrary to results reported elsewhere there was significant mean overpricing for bonds without "teasers" compared to bonds with "teasers". As Table 3 shows, mean overpricing for bonds without "teasers" (67 bp) is greater than mean overpricing with bonds with "teasers" (50 bp). It seems that "teasers" in Greek market were not used as a way to "fool" investors as it apparently happened in other markets (e.g. Swiss or German market). There was no significant overpricing of callable versus non-callable bonds for the whole bank sample. The fact that mean overpricing for callable bonds (56 bp) was less than mean overpricing for non-callable ones(71 bp) shows that callable bonds were more in demand and thus were more aggressively priced. EFG bonds were an exception since there was a significant overpricing of the non-callable issues (135 bp) versus the callable ones (52 bp). Alpha bonds seem to be more

Group	description
GPDIFF	Greek Republic SBs
BALLPDIFF	banks SBs
BCPDIFF	banks callable SBs
BNCPDIFF	banks non-callable SBs
ALFACPDIFF	ALPHA callable SBs
ALFANCPDIFF	ALPHA non-callable SBs
EFGCPDIFF	EFG callable SBs
EFGNCPDIFF	EFG non-callable SBs
FMPDIFF	SBs with "teasers"
NFMPDIFF	SBs without "teasers"
SIMPDIFF	simple SBs
COMPLPDIFF	complicate SBs
CURVPDIFF	curve SBs
RAPDIFF	range accrual SBs
SNOWPDIFF	snow ball SBs

Table 1: SB groups PDIFFs

balanced with mean overpricing for callable and non-callable of 70 bp and 40 bp respectively. Finally, consistent to the literature, complicated structures were systematically more overpriced than non-complicated structures at 10% significant level.

6   Conclusions

SB market has been extensively analysed. Greece drew the attention of the international financial community due to a sudden event that in essence demonized all SB issuance as a source of potential abnormal returns. The systematic analysis provided in this paper does not confirm this conjecture. The Greek SB market behaved in tandem with the international one and despite the popular belief that senior SBs issued by the state or by banks were severely mispriced, they were in fact priced much closer to model prices than elsewhere. Moreover local investors due to conservatism, insight or sheer luck seemed to behave

	n	mean	std	IQR	MAD	t-value	W-value	RMSE
GPDIFF	10	-0,84%	0,52%	0,00592	0,00392	-5,122 ***	0 ***	0,0109
BALLPDIFF	140	-0,65%	0,8%	0,00688	0,00599	-8,830 ***	797 ***	0,0108
BCPDIFF	116	-0,56%	0,69%	0,00594	0,00474	-8,724 ***	361 ***	0,009
BNCPDIFF	25	-0,71%	1,38%	0,02071	0,01087	-2,562 **	83 **	0,0159
ALFACPDIFF	27	-0,70%	0,66%	0,00477	0,00447	-5,543 ***	4 ***	0,0099
ALFANCPDIFF	16	-0,40%	1,31%	0,02440	0,01120	-1,210	48	0,0142
EFGCPDIFF	89	-0,52%	0,70%	0,00629	0,00479	-6,979 ***	281 ***	0,0088
EFGNCPDIFF	8	-1,35%	1,46%	0,02275	0,01213	-2,610 **	1 **	0,0222
FMPDIFF	67	-0,50%	0,72%	0,00733	0,00527	-5,669 ***	292 ***	0,0088
NFMPDIFF	80	-0,67%	1,04%	0,00624	0,00689	-5,786 ***	431 ***	0,0124
SIMPDIFF	8	0,31%	0,81%	0,01423	0,00715	1,064	10	0,0095
COMPLPDIFF	19	-0,84%	0,93%	0,01051	0,00719	-3,939 ***	1 ***	0,0131
CURVPDIFF	19	-1,25%	1,07%	0,01404	0,00839	-5,079 ***	0 ***	0,0172
RADIFF	61	-0,81%	0,76%	0,00687	0,00528	-8,328 ***	4 ***	0,0112
SNOWPDIFF	33	-0,11%	0,27%	0,00381	0,00229	-2,322 **	187 *	0,0030

Table 2: SB groups: t-test values and W-test values significant at 1%, 5%, 10% level are denoted by ***,** and * respectively.

more "rationally" than elsewhere with the usual overpricing phenomena (due to "teasers", optionality, etc.) to remain unconfirmed. A notable exception were Tier I or subordinated SBs issued by local banks that proved to be a striking source of cheap funding wrapped in a bond format. After an extensive review of the criticisms and supports for the prices SBs sold to investors, it has been shown that from a practitioner's point of view the "fair price" is a rather impractical notion that means different things to different people. This subjectivity is based on the fact that a SB, although it does provide opportunities to investors with lack of access to particular markets to take view on them in a simple and not time consuming way, this view is expressed through complicated derivatives wrapped in a bond format. These derivatives, usually swapped by the issuer to a simpler structure, cannot be priced in the same way by all the participants in the transaction, not only due to different degrees of sophistication but also due to the fact that swap counterparties use a complicated system of reserves for possible imperfections of the hedging they use. The process becomes even more complicated due to different way issuer's
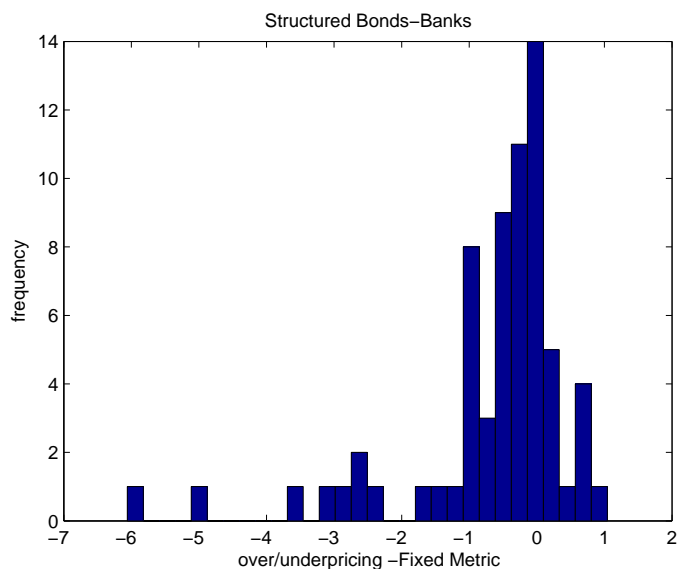
Structured Bonds−Banks

Figure 14: Relative price difference-Banks

credit is evaluated by investors and swap counterparties. It has been shown that in the presence of a swap, for a rather similar view on issuer's credit, the model price is usually smaller than the redemption price due to hedging costs, technical and possibly regulatory constraints or other kind of reserves which can be substantial for long dated structures.

It seems irrational to pretend that SBs are liquid and uniquely priced, simply because most of them combine derivatives wrapped in the credit risk of the issuer, with residual risks that cannot be hedged away. Also, it seems that the market does not completely trust the models it uses at least for complicated structures and that's why reserves are added on model prices for safety reasons. Whether a SB is sold at a price closely to model price or not should not concern the investor. Model prices are generated by arbitrage arguments and are relevant only if there is access to the underlying market. Consequently overpricing, although it conventionally measures the distance between model and transacted prices, is misleading as a guidance to the fairness of the transaction. Maybe it is worth exploring the development of a new metric that takes into consideration the inherent characteristics of the investor (attitude towards risk, sophistication level, limitations in the market) for testing the

Group A	n_1	mean	Group B	n_2 mean		U-value	
FMPDIFF	67	-0,50%	NFMPDIFF	80	-0,67%	5442*	
BCPDIFF	116	-0,56%	BNCPDIFF	25	-0,71%	1733	
ALFACPDIFF	27	-0,70%	ALFANCPDIFF	16	-0,40%	387	
EFGCPDIFF	89	-0,52%	EFGNCPDIFF	8	-1,35%	264*	
COMPLPDIFF	19	-0,84%	NCOMPLPDIFF	94	-0.56%	957	

Table 3: Average price differences for SBs with and without "teasers", and for callable and non-callable SBs. U-values significant at 1%, 5%, 10% level are denoted by ***,** and * respectively.

quality of SBs transacted prices .

It is more relevant the question whether the price the investor pays for the SB satisfies his investment objectives, is consistent to his utility function and reflects his view on the market that he could not take more cheaply using alternative ways, taking into a consideration the various internal or external limitations he may have. More importantly he should realize that by buying a SB materializes not only a view on the future course of a particular set of indices but also he takes a positive view on the credit of the issuer. It is this neglected issue that may be proved the Achilles heel of the bond (structured or not) especially in the present times of significant deterioration of credit everywhere and particularly in Greece.

Authors	Products	Maturity yrs	PDIFF range	PDIFF mean	bp/year
[51]	LINB, SPR	4	9%		225
[4]	RC	0.5-2	0.84-2.39%	1.615%	129.2
[5]	BC	2.16	2.3-4.7%	3.5%	324.07
	BC (OTM)	5	2.8%		56
[58]	CBC (OTM),2005	5	7.46%		149.2
	CBC (OTM),2007	5	5.14%		102.8
[43]	SPARQS	1.15	2.74-23.49%	8.77%	762.60
[44]	SPARQS	1.15		8%	695.65
[77]	MABRC	1.19	3.4-6%	4.7%	789.9
[70]	RC	2-3		5.92%	236.8
	KIRC	2-3		5.5%	220
[17]	DRC	2.16		1.59%	61.15
[81]	ELS-long)			4.3%	
	ELS short			7.1%	
[34]	ELS		5-10%		
[14]	ELS-long)			0.51%	
	ELS short			1.51%	
[34]	ELS		5-10%		
[20]	SB-WFC	1.08	0.02-6.29%	1.4%	129.6
	SB-FC	1.08	1.73-5.32%	3.22%	298.08
[69]	All PV	1-2		3.67%	244.66
	All Barrier	1-2		4.77 %	318
	Rainbow	1-2		5.17%	344.66
[7]	RES(implied)	2		5.37%	268.5
	RES(hist)	2		5.97%	298.5
[80]	RC	0.74	1.14-6.16%	3.89%	525.67
	DC	1.2	-1.94-22.19%	7.46%	621.66
				average	**314.6**

Table 4: Overpricing of SBs reported in the literature:
LINB:Lock-In Baskets, SPR:Spreads, BC:Bonus Certificates, CBC:Capped BC, DC:Discount Certificates,RC: Reverse Convertibles, KIRC;Knock-In RC, MABRC:Multi Asset Barrier RC, ELS:Endless Leverage Securities, PV:plain vanilla (classic, corridor, turbo, guaranteed), Barrier:(Knock-In,Partial-Knock-In,Knock-Out), RES:Reverse Exchangeable Securities, SPARQS:Stock Participation Accretting Redemption Quarterly-pay Securities, SB-FC: Structured Bonds with Fixed Coupon, SB-WFC:Structured Bonds without Fixed Coupon. OTM:Out-of The Money options.

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