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The use of derivatives by sovereigns

An analysis of pre-hedging interest rate risk ahead of auctions

Beatriz Vilarinho dos Santos Lopes

Master Thesis

presented as partial requirement for obtaining a Master's Degree in Statistics and Information Management

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The use of Derivatives by Sovereigns

An analysis of pre-hedging interest rate risk ahead of auctions

by

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Master Thesis presented as partial requirement for obtaining the Master’s degree in Statistics and Information Management, with a specialization in Risk Analysis and Management.

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism, any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledged the Rules of Conduct and Code of Honor from the NOVA Information Management School.

[Den Bosch, 02nd of December 2024]

Beatriz Vilarinho dos Santos Lopes

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# ABSTRACT

This study investigates whether interest rate swaps and German bond futures can effectively protect sovereign issuers from rising interest rates surrounding bond auction dates. The research aims to determine if using these instruments can successfully lock in the risk-free rate and shield debt management agencies from interest rate hikes leading up to auctions. The analysis employs data on benchmark bond yields from four EMU countries – Portugal, Spain, Italy, and Germany – and corresponding swap rates for various maturities, covering the period from March 2000 to December 2019. The data is categorized into bull and bear markets to refine the hedging strategies. The study excludes the period marked by the 2008 financial crisis (March 9, 2009, to August 8, 2017) due to its high volatility and focuses instead on the post-crisis period, characterized by negative interest rates. The analysis reveals that interest rate swaps provide better results than German bund futures in locking in the risk-free rate. However, both strategies show similar limitations in fully mitigating interest rate risk. While they can effectively hedge against fluctuations in the risk-free rate component of the yield curve, they leave the risk premium component, also known as the z-spread, unhedged. Consequently, both strategies' success is contingent upon the magnitude of changes in the countries' yields compared to the changes in benchmark rates. A key factor impacting the risk premium is the sensitivity of credit spreads to auction announcements, especially for Portugal and Spain. A phenomenon exacerbated by the unpredictability of auction timing and frequency, leading to increased volatility in the days leading up to auctions. Future research could explore alternative financial instruments and strategies for pre-hedging interest rate increases around auction dates. Furthermore, investigations into the liquidity, regulatory, and operational implications of employing these derivatives would provide valuable insights for debt management agencies.

KEYWORDS

Sovereign debt; Futures; Swaps; Interest Rate; Bonds; Interest Rate Risk

Sustainable Development Goals (SDG): 

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LIST OF ABBREVIATIONS AND ACRONYMS

ADF	Augmented Dickey-Fuller
DMA	Debt Management Agency
DMO	Debt Management Office
EG	Engle-Granger
EMU	European Monetary Union
GE	Germany
IR	Interest Rate
IRS	Interest Rate Swap
IT	Italy
JJ	Johansen-Juselius
PT	Portugal
SP	Spain

1. INTRODUCTION

In order to finance budget necessities or investment projects, government entities and corporations issue fixed-income securities, also known as bonds. Bonds are debt securities where the issuer (borrower) is committed to paying back the lender the amount borrowed and periodic interests based on this amount for a given period. For sovereign bonds, this is done via debt management agencies.

Sovereign bonds are predominantly considered a safe investment since this type of security is considered low-risk as the issuer is the national. As mentioned previously, the purpose of issuing these instruments is for the government to raise capital to finance projects or day-to-day operations. (Martellini & Priaulet, 2003)

The issuance of these debt instruments is carried out through either bank syndicates or auctions. Debt management offices typically use syndicates regarding new market segments, allowing them to place a significant amount at once, creating more liquidity for this new instrument. (Wolswijk & Haan, 2005)

On the other hand, debt agencies can also issue existing securities through auctions, where multiple underwriters, also known as primary dealers, are invited to attend and place their biddings. The auctions can be executed through three different methods: the uniform auction, the discriminatory auction, or the mixed auction, with the first two mechanisms being the most commonly used.

Throughout Europe, the three methods are used when auctioning treasury bills and notes, and each country decides which method is the most suitable for their auctions. For instance, Portugal and Italy use the single price auction for treasury bonds and the discriminatory auction for treasury bills. In contrast, Spain uses the hybrid method for treasury bonds and bills. When governments issue debt, one of the risks that they become exposed to is interest rate risk. In other words, the debt management office (DMO) never knows *ex-ante* what the cost of the debt (yield) issued will be. Some studies prove that after the auction announcement, the yields tend to rise in those days between the announcement and the day of the auction and decline in the days after.(Beetsma, Giuliodori, De Jong, & Widijanto, 2013)

Thus, to protect themselves from an increase in interest rates in the secondary market, which would lead to higher issuance costs, DMOs could hedge their position by entering into a derivative contract such as interest rate swaps or bond futures. To hedge their exposure to interest rate movements, the debt management agency could either do pre-auction or post-auction hedging.

Assuming the yield curve is only comprised of the risk-free rate plus the risk premium, the pre-hedging strategy consists of entering an interest rate swap or bond future for a short period to lock the risk-free rate element and protect against increases in interest rates that would ultimately increase the yield of the bond at the issuance date. This strategy will be explained in more detail later in this paper.

Post-auction hedging is a commonly used strategy to reduce the bond portfolio’s duration. This is done by entering an interest rate swap, receiving the long-term rate, and paying the short-term rate, thus transforming the long-term debt into a short-term debt. This strategy allows the DMOs to continue to issue longer-term debt to maintain liquidity of the benchmarks and reduce the refinancing risk while at the same time benefiting from the lower short-term rates.

The swap market began in 1981 when the World Bank entered into an over-the-counter contract with IBM, in which each firm agreed to make interest payments to each other. Since then, the swap market has grown exponentially and is now one of the most important derivative markets. As mentioned before, a swap is an over-the-counter agreement where two parties exchange the cash flows in the form of different financial instruments in the future. (Hull, 2016)

Futures are traded on an exchange and is an agreement between two counterparts who agree to sell or buy an asset at a predetermined price and time in the future. The features of these contracts are typically standardized and specified by the exchange. The largest exchanges are the Chicago Board of Trade (CBOT) and the Chicago Mercantile Exchange (CME), which form the CME Group. (Hull, 2016)

Prior to the eurozone crisis, hedging interest rate risk was of great importance since rates back then were significantly higher, leading to greater borrowing costs, and it was in the best interest of the debt management agencies to do whatever they could to lower it. During the eurozone crisis and due to the monetary policy imposed by the European Central Bank (ECB), interest rates were at an all-time low, reaching negative values, something unprecedented.

Since mid-2022, in an attempt to beat inflation caused by the COVID pandemic and worsened by the Ukraine-Russia war, the ECB increased interest rates and is now back to the pre-European crisis level.

Before the Eurozone crisis, pre-hedging auctions might have succeeded in decreasing borrowing costs. However, after the crisis, interest rates were so low that the need to hedge movements in interest rates was no longer a priority. With the recent increase in interest rates to equivalent levels before the crisis, pre-hedging auctions might be a successful strategy to protect against increases in interest rates.

This theoretical paper aims to understand if pre-hedging auctions using German bond futures and interest rate swaps can lower the borrowing costs of Sovereign issuers. If so, why aren’t the debt management agencies doing it?

2. LITERATURE REVIEW

2.1. Sovereign Bonds and Auctions

2.1.1. The bond market

In 2000, the bond market undertook major developments mainly linked to the introduction of the euro. (European Central Bank, 2001)

The introduction of the single currency brought increased competition between governments, as prior to the euro, they had benefited "from a quasi-monopoly situation." Whereas after, all countries were now competing in the same pool of funds.

This, in turn, led to an improvement in transparency and standardization of sovereign bonds, resulting in a relatively homogeneity between the debt instruments in regard to their financial characteristics and creditworthiness.

As a direct consequence of a larger market of investors, national treasuries could now include a higher number of non-residence banks to their number of primary dealers.

A second trend observed was the increase in the average size of outstanding bonds with the end goal of enhancing liquidity. Further, bond issuances concentrated mainly in the 10-year segment of the yield curve to take advantage of the low yields and to boost liquidity.

In 1999 and 2000, the fiscal performance of the euro area exceeded expectations. With the improvements in the budgetary balance, the share of outstanding government bonds declined, reducing the net borrowing requirements for governments. This allowed the EU members to undertake buyback programs or carry out bond exchanges that targeted illiquid and short-date debt instruments.

A complementary study conducted by (European Central Bank, 2004) showed that the introduction of the euro improved access to markets within the EU, allowing investors to diversify their portfolio by investing in other countries. Consequently, reducing the "home bias" of European investors and promoting investments within the EU.

The introduction of the single currency in parallel with the integration of the European financial markets established an increasing role in credit ratings. By removing the currency risk, investors could focus on the creditworthiness of the bonds.

Affirming what was already established by (European Central Bank, 2001), (European Central Bank, 2004) reinforces the homogeneity of the characteristics of the bond market, with fixed coupon still being the preferred type. Unlike the previous study, maturities are no longer concentrated on the 10-year segment of the curve and are more distributed in all segments of the spectrum (ranging from 1 to 30 years). The presence of issuers is more homogeneous up to the 10-year maturity, with a bigger fragmentation in the long-term end of the spectrum as only bigger countries were able to issue in the whole maturity spectrum.

According to (European Central Bank, 2004), the introduction of the euro resulted in one of the world's biggest markets for sovereign issuance. The European government bond market ranked third after the US and Japan, with the three accounting for 84% of all government bonds outstanding. The euro market distinguishes itself from the remaining due to the abundance of different issuers with different creditworthiness.

Opposite to the budget surplus in 2000, there was an increase in funding needs due to lower economic growth, resulting in increased issuance activity in the member states. A multitude of factors eased the placement of these issuances; firstly, the historically low yields created optimal conditions for countries to issue long-term debt. Secondly, the high creditworthiness of the securities increased their acceptance in the repo transactions and lending facilities.

Furthermore, the study concluded that the government yield spreads tightened. Before the introduction of the euro, yield spreads were determined by four main drivers: outlook of exchange-rate fluctuations, different tax treatment by different countries, credit risk, and liquidity.

With the introduction of the euro, currency risk was no longer a concern, and taxation differences could be somewhat disregarded as the “tax package” was being worked on by the EU with the main goal of decreasing the discrepancies between member states.

Thus, yield spreads were now predominantly comprised of credit premiums of the EU Member States and liquidity of the market.

(European Central Bank, 2004) argues that even though the preferred method of issuance is the traditional auction method, combining an auction with syndication was becoming a trend.

During the European crisis, government bond yield pricing rose to unprecedented levels since the introduction of the euro. A number of papers studied the drivers of such an increase, specifically assessing the role of fiscal conditions in explaining yield differentials. (Haugh, Ollivaud, & Turner, 2009) analyzed the 10-year yield spread between ten-euro countries and Germany throughout December 2005 and June 2009. The study concluded that the expected deterioration of the fiscal condition and high debt-service ratios contributed substantially to the widening of the spreads, resulting from investors becoming more risk-averse during turmoil times, requiring more compensation to offset the risk of the country defaulting.

Complementing the previous study, (Sgherri & Zoli, 2009) analyzed the government yield spreads between ten euro countries and Germany from January 2003 - March 2009. The study confirmed what was previously mentioned: Investors required a higher credit risk premium in response to the detriment of the fiscal positions, distinguishing more between sovereign issuers than in the past.

2.1.2. Auction Mechanisms

The debate regarding which type of auction mechanism is best for optimal results by sovereign entities dates back to 1960 when Milton Friedman argued that a discriminatory auction eliminates uninformed investors due to the “winner’s curse” and draws in more informed players. He concluded that a discriminatory auction leads to lower revenues, while the uniform mechanism leads to bigger participation, resulting in less collusion and higher revenues.

In the uniform price auction, also known as the single-price auction, the instruments are awarded to those who bid above the cut-off price, with all bidders paying the same price (cut-off price). In the discriminatory auction, also known as the multiple-price auction, the instruments are awarded to those who bid above the cut-off price; however, each bidder pays the price they bid.

Additionally, the Spanish Treasury uses the mixed auction mechanism, a hybrid method combining characteristics from the single-price auction with attributes from the multiple-price auctions.

According to the Spanish treasury webpage, in this method, all bids above or at the stop-out price are accepted, and the allocation price is as follows: if the bid price is between the minimum and the rounded-up weighted average price of the winning bids, then pays the price bid, otherwise pays the rounded-up weighted average price.

This paper will focus on the uniform price and discriminatory auctions.

Throughout the years, numerous empirical studies have analyzed the outcome of these two mechanisms. (Hortaçsu & McAdams, 2010) In their simulation of the Turkish Treasury, auctions concluded that changing from discriminatory auction to single price would not significantly increase the revenue. . Comparably, (Barbosa, De Silva, Yang, & Yoshimoto, 2022) yielded the same results when investigating whether the treasury securities issued by two Chinese Government Treasury security issuers should be sold under a discriminatory or uniform mechanism.

(Kang & Puller, 2008) Studied which format results in higher revenue using the Korean Treasury as their sample. They concluded that using the discriminatory mechanism resulted in higher revenue. (Armantier & Lafhel, 2009) who simulated using a sample of the Canadian government securities auctions and (Philippe, Preget, & Visser, 2004) Using the French Treasury securities auction reached an equivalent conclusion: discriminatory auctions yield a slightly higher revenue.

Conversely, (Armantier & Sbaï, 2006) used a sample from the French Treasury auctions and concluded that changing from a discriminatory to a uniform price format would benefit the French Treasury. (Castellanos & Oviedo, 2008) Analysis of the Mexican Treasury securities auctions determined that the uniform price resulted in higher revenues when compared to the discriminatory mechanism.

This suggests that the debate on which mechanism favors the issuer best is still unsettled.

2.1.3. THE V-SHAPED PATTERN

(Fleming, Nguyen, & Rosenberg, 2007) studied how US treasury dealers manage their inventory risk in fixed-income markets, specifically around treasury auctions and their impacts on the secondary market, also known as the “auction cycle.” The Treasury fixed income market is singular as it is known fairly in advance when there will be an increase in inventory and for how much. Another singularity is that the primary dealers who underwrite these fixed-income instruments are also the ones who make the secondary markets in the securities.

(Fleming et al., 2007) Examines the transitory price effect associated with auctions and the reallocation of the new issuance to a broader set of participants by the dealers. Their study shows a positive yield change before the auctions and a negative yield change after the auctions. The increase in supply causes the depreciation of the bond price prior to the auction. This, in turn, allows the dealers to be compensated for their inventory risk by buying treasuries at a lower price during auction weeks and selling them when they have appreciated in the subsequent week.

Complementary to this study, (Lou, Yan, & Zhang, 2013) also investigated the effect of US Treasury auctions in the secondary market. Similar to (Fleming et al., 2007), they concluded that prices tend to decline before the auctions and recover shortly after. However, they associate the decline in prices not with the increase in supply but with the primary dealer's limited risk-bearing capacity.

Due to this, primary dealers hedge the risk they expect to acquire at auctions by short-selling similar securities before the auction, thus driving downward the price in the secondary market. (Lou et al., 2013) also concluded that the price impact in the secondary market is higher when the auction size is larger, when interest rates are more volatile, or when dealers have more capital constraints.

Parallel to the studies above, (Beetsma, Giuliodori, de Jong, & Widijanto, 2016) provided more insight into the price effects of sovereign debt auctions during economic and financial crises. The study concentrates on two countries: Germany and Italy. During the crises, their public debt yields suffered substantially but in opposite ways. While Germany's yield fell to unprecedentedly low levels, Italy's rose dangerously high.

They concluded that Italy's secondary market yields increase when there is an upcoming action, especially noted during the crisis, unlike Germany, where the effect of the auction announcement has no or small effect. Furthermore, these results confirmed the framework used by the authors, where primary dealers require higher compensation for inventory risk when the market is more volatile.

2.1.4. THE SOVEREIGN BOND YIELD

The sovereign bond yield reflects the return investors require to lend money to a government when purchasing its bonds. It also reflects the government's creditworthiness and the current or expected economic conditions.

Different factors can affect the bond's yield related to risk, time, and expected returns, such as credit risk, inflation, liquidity, and more. Therefore, it can be concluded that the sovereign bond yield can be represented as:

$$\text{Yield} = \text{Risk-Free Rate} + \text{Risk Premium}$$

Where the risk-free rate is the benchmark typically associated with government bond yields and swap rates, which are considered to be risk-free. While the risk premium is comprised of all the factors that can affect the bond's yield, aforementioned.

Since this paper aims to quantify how effective swaps and German Bund futures are to pre-hedge bond auctions, swap rates, and German bond yields will be used as benchmarks (risk-free rate). This will allow to hedge the risk-free component of the yield, while the risk premium will remain unhedged.

Further, for this analysis, the risk premium will only be comprised of credit risk, reflecting the additional return an investor requires for the added credit risk compared to the risk-free benchmark. This can be explained as the Zero Volatility Spread (z-spread).

The Z-spread assesses a bond's risk premium over the risk-free rate. It is the amount added to the benchmark yield curve to equate the present value of the bond's cash flows.

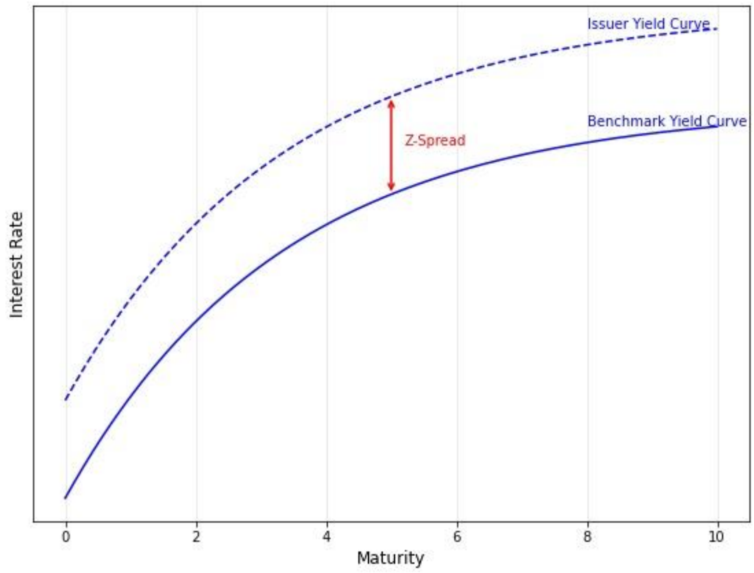

Figure 2-1 - Z-Spread

2.2. THE FUTURES MARKET

2.2.1. OVERVIEW OF GERMAN BOND FUTURES AND THE ROLE IN HEDGING SOVEREIGN DEBT

Futures are a type of financial derivative that allows investors to hedge against price fluctuations or speculate on future price movements of the underlying asset by buying or selling the asset at a predetermined future date and price. These contracts are standardized agreements with specified quantity, delivery date, price, and transaction characteristics. (Bodor & Carlier, 2024)

Bond futures are used to trade fixed-income securities, such as sovereign bonds, at a future date for a predetermined price. This instrument allows investors to hedge against interest rate risk or speculate on bond price movements by taking a position on the future price of the underlying asset without owning the bond itself. (Bodor & Carlier, 2024)

Bond futures are traded on exchanges, as opposed to forward contracts, which are traded over-the-counter and are sensitive to fluctuations in market factors such as interest rates and credit ratings mirroring the underlying bond's behavior. (Bodor & Carlier, 2024)

With the introduction of the euro, the spread of the EMU government bonds diminished mainly due to the fact that market participants assumed all countries had equally low risk of defaulting. Since the yield spreads between the EMU country's sovereign bonds were only marginal, interest rate risk could be efficiently hedged using German Futures contracts, such as the Bund, Bobl, and Schatz futures. This held until mid-2008, when the sovereign debt crisis began, and interest rate risk was the dominant factor for European government bond portfolios. (Bessler & Wolff, 2014)

In anticipation of a sovereign crisis at the end of 2008, particularly associated with Greece, Portugal, Ireland, Italy, and Spain, the spreads of government bonds of these countries were widening relative to German bond yields. Hence, managers of European bond portfolios had to manage interest rate risk and create new strategies to deal with sovereign risk. (Bessler & Wolff, 2014)

Since the beginning of the sovereign debt crisis in mid-2008, the central bank supplied short-term liquidity, contributing to a steepening of the yield curve and adding further complexity to hedging with a single-maturity futures contract. To address the new market challenges, EUREX introduced short-, mid-, and long-term Euro Italian BTP futures, thus complementing the German government bond futures. This enabled investors to hedge interest rates with futures contracts on bonds with lower (Germany) and higher (Italy) sovereign risk.(Bessler & Wolff, 2014)

(Bessler & Wolff, 2014) analyzed hedging strategies for European bond portfolios before and during the sovereign debt crisis, using German and Italian government bond futures. The study concluded that prior to the crisis, futures on German sovereign bonds were efficient instruments to hedge government bond portfolios. However, a composite hedge combining German and Italian futures was more effective during the crisis than a single-instrument hedge. Further, they tested the effectiveness of the "bucket hedging" strategy, where the bond portfolio is divided into different sovereign risk buckets, which are hedged individually. They concluded that it results in a superior hedging strategy compared to hedging all portfolio risks simultaneously.

2.2.2. The Cost-of-Carry Theory

Futures prices and spot prices are related through a cost-of-carry relationship. According to (Hull, 2016), this theory formulates that the price of a futures contract at time t should be equal to the spot price of the underlying asset plus the cost of holding the asset over time from t to $t + n$.

Depending on the underlying asset, these costs can vary from financing, storage, transportation, insurance, and convenience yield. Applying this to bond futures, where the underlying asset is considered an investment asset, the relationship between the future and the underlying can be translated as:

$$F_0 = (S_0 - I)e^{rt} \quad (2.1)$$

Where F_0 and S_0 are the prices of the future contract and underlying asset at inception, r is the risk-free rate, and T is the time to maturity (Hull, 2016).

As highlighted in (Alizadeh & Nomikos, 2004), deviations between the futures price and the underlying asset allow traders to exploit riskless arbitrage profits by buying the underlying and selling the futures contract, also known as the "cash-and-carry" arbitrage.

2.3. THE SWAP MARKET

2.3.1. THE INTEREST RATE SWAP MARKET

The over-the-counter swap market began in 1981 when IBM negotiated a currency swap with the World Bank. Since then, the swap market has grown extraordinarily, becoming a key instrument in the over-the-counter derivatives market. (Hull, 2016)

At the beginning of the century, and with the introduction of the euro, the interest rate swap market continued to expand. Due to the lack of a single and well-defined benchmark sovereign yield curve, the swap market became a reference for market participants seeking a liquid and more homogeneous source, especially for the valuation of non-sovereign bonds. (European Central Bank, 2001)

The swap spread behavior also reflects the swap market expansion throughout 2000. Euro swap spreads rose to levels seen after the 1998 crisis, and it was partly driven by cyclical considerations as well as changes in the structure of the euro area capital markets. (European Central Bank, 2001)

The reduction in the net supply of euro-area sovereign bonds in 2000 resulted in a diminished correlation between government bond yields and other euro-denominated fixed-income securities, such as non-sovereign bonds and swaps. This reinforces the use of swaps for hedging and valuation.. (European Central Bank, 2001)

Additionally, the introduction of the single currency promoted a shift of bond issuances in the private sector from the US dollar market to the new euro market, contributing to the development of the swap market and the evolution of swap spreads. (European Central Bank, 2001)

The global over-the-counter (OTC) derivatives market is a significant part of the financial system, where derivatives, repurchase offers, or bonds are traded between banks and financial institutions. According to (Fontana & Holz Auf Der Heide, 2019), the Interest Rate

Swap (IRS) market is one of the largest segments of the OTC derivatives market, accounting for more than 60%, and is mainly traded OTC in EU.

During the 2008 global financial crisis, the market's core was largely centralized on a few dealers, which were connected to multiple other traders. This allowed the risk of rapid propagation over the financial system, making the OTC derivatives market a significant epicenter of the financial crisis in late 2008, especially with the downfall of Lehman Brothers, which contributed extensively to systemic risk and transmission of counterparty credit risk among major banks. (Fontana & Holz Auf Der Heide, 2019)

Because of the private nature of bilateral transactions, OTC derivatives are considered "dark markets" (Duffie, 2012), creating a scarcity of comprehensive data. After the crisis, in an attempt to address opacity, counterparty credit risk, and contagion risk, several measures were put in place by the Dodd-Frank Wall Street Reform and Consumer Protection Act in the US and the European Market Infrastructure Regulation (EMIR).(Fontana & Holz Auf Der Heide, 2019)

These are, amongst others, reporting of all OTC derivatives transactions in trade repositories, including the transaction details, modifications, and cancelations to improve post-trade transparency. Obligation to centrally clear standardized instruments via the authorized central clearing counterparties (CCPs); since 2016, all EU trades of major market participants in basis, fixed-to-float interest rate swaps, forward rate agreements (FRAs) and OIS in EUR, GBP, JPY, and USD have to be centrally cleared. Increased capital charges and margining for all non-centrally cleared derivatives trades for risk mitigation, covering both the current exposure (variation margin) and the potential future exposure (initial margin). (Fontana & Holz Auf Der Heide, 2019). Central banks within the European System of Central Banks (ESCB), debt management agencies and the Bank for International Settlements are exempt from central clearing as stated in article 1(4) of the European Market Infrastructure Regulation.

(Fontana & Holz Auf Der Heide, 2019) studied the anatomy of the euro area IRS market, providing new evidence on the structure and activity of the IRS swap market, which can be twofold in terms of I) risk absorption and II) the impact of the regulatory reforms and the role of Basel III capital and liquidity ratios in influencing trade activity.

They conclude that the market structure regarding trading activity is not just concentrated on a few global dealers, highlighting the significance of other institutions that substantially contribute to trading activity.

Furthermore, they show that variables other than bank size explain the differences between trading activities. Basel III and liquidity ratios play an important role in a market where counterparty credit risk is strongly reduced due to mandatory clearing.

The study confirms previous claims by (Haynes, McPhail, & Zhu, 2018) that the leverage ratio enforced by Basel III may constrain the trading activity of interest rate swaps. Firms with a larger capital over total exposure ratio have lower trading activity, while for large banks, different leverage ratio levels influence their trading activity; firms with larger capital over total exposure ratio have lower trading activity.

2.3.2. BASICS OF INTEREST RATE SWAPS

An interest rate swap is a bilateral agreement between two counterparts to exchange cash flows in the future. One company agrees to pay interest at a predetermined fixed rate on a predetermined notional for a predetermined number of years. In exchange, the other counterparty agrees to pay interest at a floating rate on the same notional for the same period of time. (Hull, 2016)

Interest rate swaps are typically used to adjust structured payment flows in asset-liability management, hedge interest rate risk, or take on such risks for trading purposes. Banks resource to IRS to hedge interest rate risk in their loan books or bond portfolios, converting the cash flows of a bond issuance or intermediation by offering hedging opportunities to other banks and non-financials (Fontana & Holz Auf Der Heide, 2019)

The euro area typically uses the Euribor unsecured money market rate as the underlying interest rate, while the Libor rate is used for GBP and USD transactions. (Fontana & Holz Auf Der Heide, 2019)

At inception, an interest rate swap has a net present value of zero, i.e., the present value of the position of the fixed rate payer and the floating rate payer are equal. Typically, the difference between the current floating leg and the initially determined fixed leg ("the spread") is re-calculated every half-year. Once the spread is calculated, one of the counterparts will have to pay the difference, depending on whether it is positive or negative. (Fontana & Holz Auf Der Heide, 2019)

Counterparty 1 (the buyer) pays:	Payments	Counterparty 2 (the sellers) pays:
Five-year fixed rate	1%——>	five-year floating rate
1%	<——EURIBOR + 10 BP	Three-month EURIBOR + 10BP

Figure 2-2 - Interest rate swap schema (Fontana & Holz Auf Der Heide, 2019)

2.4. RISK MANAGEMENT

Theories on the optimal strategy for government debt management have highlighted several goals over time. These include macroeconomic stabilization, developing national financial markets, supporting monetary policy, and minimizing costs and risks. (Wolswijk & Haan, 2005)

In 1963, (Tobin, 1963) viewed government debt management mainly as a tool for macroeconomic stabilization, with minimizing the interest costs playing a smaller role and risk mitigation not even being considered. Therefore, when there is an economic upturn, new debt issuance should be focused on longer maturities, consequently driving up long-term interest rates and contributing to an economic slowdown.

According to (Barro, 1999), under his approach, tax smoothing is the core government objective; varying debt levels over time are permitted to allow smooth tax rates, which is welfare-improving as changes in tax rates create economic imbalances. This can be achieved by issuing debt with interest payments dependent on certain developments, e.g., GDP-indexed debt, where the returns are linked to the GDP growth rate. In times with a high growth environment, investors will benefit from a higher return on these bonds without the government having to increase tax ratios, as the high growth boosts the budget balance via built-in stabilizers. A combination of conventional instruments such as nominal bonds, indexed bonds, and foreign currency bonds may produce a similar result in the absence of GDP-indexed bonds.(see (Missale, 1999)). (Wolswijk & Haan, 2005)

With the new fiscal framework in EMU, (Missale, 2000) argues that the main goal of debt management is deficit stabilization. He proposes that an appropriate selection of debt instruments based on inflation and real GDP-sensitivity of interest payments can minimize the fluctuations in the deficit-to-GDP ratio.

The ideal framework depends on the signs and strengths of the correlations between inflation, real GDP, and interest rates. Missale modeled the changes in optimal debt management under EMU since the correlations previously mentioned were affected by the introduction of the euro and the single monetary policy. (Wolswijk & Haan, 2005)

Considering that the European Central Bank prioritizes price stability, Missale's model concludes that combining conventional long-term debt and inflation-indexed debt would be the optimal strategy for deficit stabilization. (Wolswijk & Haan, 2005)

In practice, the main objective of debt management agencies in the euro area is to guarantee financing at the lowest cost with acceptable risks. The operational targets for debt management units vary significantly and are usually based on asset-liability studies or cost-at-risk models, measuring interest rate costs against budgetary risks. These can be expressed as target (range) for the average maturity or the (modified) duration, dependent on certain restrictions, namely quantitative limits on using interest rate swaps.. (Wolswijk & Haan, 2005)

For example, in 2004, the French debt agency had a target of an average maturity of 5.3 years (after interest rate swaps), implying a reduction of almost half a year compared to 2003. After focusing on duration, the Netherlands had a target of the total annual refinancing amount (including swaps) set at 9% of GDP.. (Wolswijk & Haan, 2005)

When comparing the objectives of the academic literature with the goals of the debt management agencies, they are barely alike. Firstly, active support of macroeconomic policies is no longer a priority, reflecting lower confidence in the efficiency of active demand management as well as consolidated capital markets that limit the scope for national debt policies. (Wolswijk & Haan, 2005)

Secondly, tax smoothing has lost ground as a debt management goal. Debt managers are more focused on reducing government interest payments and avoiding the possible risk of large fluctuations in these payments instead of prioritizing the budget to avoid large tax changes. (Wolswijk & Haan, 2005)

Possible causes for the gap between the theory and the practice of debt management can be attributed to the nature of the theoretical models used or differences in accounting conventions, resulting in different focuses. (Leong, 1999) Another factor is that debt managers and policy makers generally focus on annual budgets, while most theoretical models focus on the market value of the debt portfolio. (Wolswijk & Haan, 2005)

According to the manual on government deficit and debt, many governments use swaps as a financial tool for risk management purposes. Regarding debt, these instruments can be used to hedge exchange risk for debt issued in foreign currency, enhance the liability portfolio, hedge future issuances, and minimize the cost of the debt based on the current and expected yield curve. (Eurostat, 2019)

Government debt managers resort to swaps for different reasons related to, for instance, debt strategy or structure of debt. Interest Rate Swaps can be used to change the maturity of a debt by transforming a long-term debt into a short-term debt - the government pays a (floating) short-term rate and receives a (fixed) long-term rate. Another use of swaps can be to reduce refinancing risk based on possible changes in the yield curve. (Eurostat, 2019)

In 2006, (Wolswijk & de Haan, 2006) studied the changes in debt managers' strategies. They concluded that there was an increase in the use of interest rate swaps by the euro area debt managers to reduce the duration of the outstanding debt. This was done by entering into a swap where the government receives the long-term interest rate and pays the short-term interest rate.

They argue that the main factor in the increase in the use of interest rate swaps can be mainly attributed to the reduced government financing needs. Considering this and the need to issue high volumes of benchmark bonds to remain liquid in the secondary market, debt managers used swaps to steer the risk profile of government debt.

Swaps provide more flexibility in debt management by separating liquidity from the risk profile. Although these swaps were not new instruments, the European swap market needed to be bigger for governments to use without disturbing the markets. The introduction of the single currency seized this risk.

Using interest rate swaps reduces financing costs by allowing the debt management agencies to continue issuing the benchmark 10-year bond while profiting from the cost advantages of short-term interest rates.

There is a gap in the literature regarding pre-hedging interest rate risk around auction dates. This paper tries to explain the effectiveness of using IR swaps and German bond futures to hedge interest rate increases before the auction date. These strategies will be explained later in this paper.

3. METHODOLOGY

3.1. DATA AND DEFINITION OF BULL AND BEAR MARKETS

This study is based on the daily yields on benchmark bonds from four EMU countries and swap rates for different maturities: 2 years, 5 years, 7 years, 10 years, 15 years, and 30 years. The countries under the scope of this analysis are Portugal (PT), Spain (SP), Italy (IT), and Germany (GE), with the latter being the benchmark country. All series are obtained from Bloomberg and observed between March 6, 2000, and December 31, 2019.

As discussed in the introduction, the main objective of this study is to understand if swaps and futures are viable instruments for pre-hedge bond auctions. To do so, information was collected from each DMO webpage regarding the results- such as auction date, yield rate, and nominal amount- from auctions during the period in question.

The data was first divided and categorized into bear and bull markets to optimize the hedging strategy and understand which type of market fits better. (Leschinski, Voges, & Sibbertsen, 2018)

The first period is determined by the crash from the Dot-com bubble (from 01/01/1999 until 05/03/2000); the second period was the recovery and boom, which lasted from March 12, 2003, until May 31, 2007, followed by the subprime mortgage crisis and it lasted until March 8, 2009.

According to (Leschinski et al., 2018), in the recovery that followed this crisis, it could be argued that there were several short bull- and bear-market periods, and the mechanisms driving the pricing of EMU government bonds were changed permanently with the beginning of the EMU debt crisis in October 2009. This fact is confirmed empirically by previous studies (Christiansen, 2014; Ehrmann & Fratzscher, 2017; Pozzi & Wolswijk, 2012). This period was characterized by the (Leschinski et al., 2018) analysis as the crisis period (from March 9, 2009 until August 8, 2017).

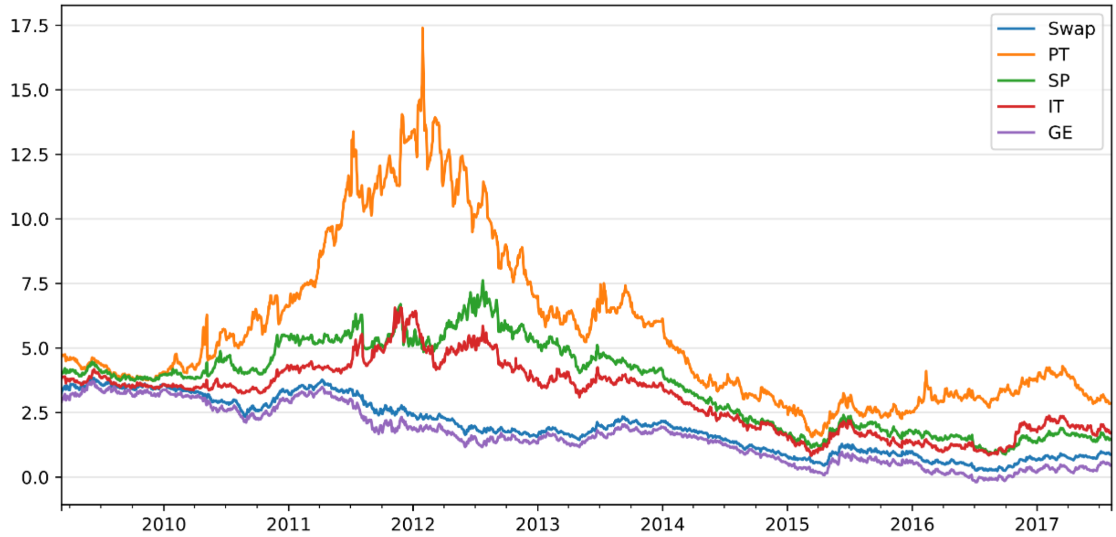

Figure 3-1 - 10Y interest rate during the crisis period

The latter period is marked by high volatility and high yields due to the uncertainty lived during those years; therefore, for this study, this period will not be considered, but instead, the period post-crisis beginning on August 9, 2017, and ending on December 31, 2019; this period is marked and distinguishes from the others under this study since this is the first one with negative interest rates. The timing of these periods is shown in Table 3-1[1].

Table 3-1 - Definition of bull- and bear-market periods

	Begin	End
Bear 1	06/03/2000	11/03/2003
Bull 1	12/03/2003	31/05/2007
Bear 2	01/06/2007	08/03/2009
Post-Crisis	09/08/2017	31/12/20019

[1] See appendix for graphic representation of these periods.

3.2. AUGMENTED DICKEY-FULLER TEST

With the dataset divided into bull- and bear-market periods, it is essential to grasp if there is a causal relationship between swap rates and bond yields, Germany's yields, and the remaining countries' yields. To do so, bivariate cointegration and the Granger causality test will be used, where the first one captures the long-run co-movements or equilibrium relationship between two variables. At the same time, the latter analyses the short-run dynamics of the variables. (Ibrahim, 2000)

As (Ibrahim, 2000) noted, although the methods might seem suitable, two critical points must be highlighted. Firstly, the cointegration approach can still be used even if the theoretical foundations for the link between the variables are viewed as weak. In fact, according to (Enders, 1995)), the existence of cointegration between a set of variables does not necessarily imply the presence of the equilibrium relationship generated by market forces; it "may be causal behavioral, or simply a reduced-form relationship among similarly trending variables" (p.359). Secondly, the bivariate framework usually employed may not be adequate since the theoretical explanations - outlined above - indicate the existence of other variables that might interact with the variables, in this case, with swap rates and bond yields. (Ibrahim, 2000)Before testing for cointegration, it is necessary to examine the stationary properties of the dataset first using the augmented Dickey-Fuller (ADF) test. It assesses whether an autoregressive process has a unit root, i.e., $a = 1$. The null hypothesis H_0 is that the process (3.1) has a unit root, i.e., $a = 1$, meaning that a unit root can represent the time series and, therefore, is not stationary. The alternative hypothesis is that the process P is stationary, so $|a| < 1$ suggests the time series does not have a unit root; hence, it is stationary and does not have a time-dependent structure (Meissner, 2018). The augmented Dickey-Fuller test can be formulated as follows:

$$\Delta\varkappa_t = \alpha + \beta_t + \rho x_{t-1} + \sum_{i=1}^{k} \varphi_i \Delta x_{t-i} + \varepsilon_t \tag{3.1}$$

And

$$H_0: a = 1;\ H_1: a < |1|$$

Table A. 1 in the annex presents the results of this test. It is divided into two groups: the first one (on the left) presents the test statistics for the series' log levels, while the right side of the table presents the test statistics for their first differences.

As can be observed, the null hypothesis of unit roots cannot be rejected in most cases for the log levels, except the bull period 15Y GE yields and the second bear period 15Y IT and 30Y PT, SP, and IT yields, the null hypothesis is rejected for a significance level of 5% and 10%.

On the other hand, the null hypothesis of unit roots in the first log differences of the variables is rejected in all cases. So, considering a significance level of 1%, the results suggest that the variables are non-stationary and integrated of order 1, $I(1)$.

3.3. COINTEGRATION TEST

In 1987, Nobel laureates Robert Engle and Clive Granger introduced cointegration tests for long-run relationships in two or more time series. As noted by (Ibrahim, 2000), if a set of variables are individually non-stationary and integrated of the same order and their linear combination is stationary, then they are cointegrated. In addition to suggesting a long-run relationship between the variables, cointegration also "rules out non-causality between the variables" (p.39).

According to (Miller, 1991) and (Miller & Russek, 1990), when two variables are cointegrated, causality in the Granger sense must exist between them in at least one direction, which indicates two significant forces that might cause the changes in the variables. One is short-run interactions between the variables, which suggest that one variable responds to changes in another variable. The other is the adjustments taken by the variables when deviations from an equilibrium path occur.

However, when two variables are not cointegrated, it suggests there might only be short-run interactions between them (Ibrahim, 2000), i.e., changes in one variable may cause temporary changes in the other variable that do not persist and, therefore, do not affect the long-run equilibrium. (Kurita & Nielsen, 2009)

To test for cointegration, two methods are going to be employed – the residual-based test of (Engle & Granger, 1987) and the VAR-based tests of (Johansen, 1988) and (Johansen & Juselius, 1990). The Engle-Granger (EG) test is a two-step method: First, it creates residuals based on an OLS estimation of a pre-specified cointegrating regression, then performs a unit root test of the residuals.

The null hypothesis for the EG test is that no cointegration exists, so if the residuals are considered stationary, the null hypothesis is rejected. (Ibrahim, 2000) The hypothesis can be formulated as follows:

H_0: No cointegration exists; H_1: Cointegration exists

However, this method has some known limitations: it can be sensitive to the variable used as a conditioning left-hand side or normalized variables, especially if it is more than one variable;

another limitation is that it is a single equation model. Recent cointegration tests have addressed these drawbacks, one being the Johansen-Juselius. (Ibrahim, 2000)

The Johansen-Juselius (JJ) test is based on the maximum likelihood estimation of the VAR model. It returns two statistics: (i) the trace and (ii) the maximal Eigenvalue, which tests for the presence of *r* cointegrating vectors.

The null hypothesis for the trace test is that there are at most *r* cointegrating vectors against the alternative of r or more cointegrating vectors. The maximal Eigenvalue tests for *r* cointegrating vectors against the alternative of *r* + 1 cointegrating vectors (Ibrahim, 2000). These hypotheses can be formulated as:

$$H_0: r = r_0; H1\ r \geq r_0$$

And

$$H_0: r = r_0; H_1: r = r_0 + 1$$

Unlike the Engle-Granger test, the JJ approach considers all variables as potentially endogenous, avoiding the problem of normalizing the cointegrating vector on one of the variables and allowing for more than one cointegration relationship.

Moreover, it is observed to be more potent than the EG test. However, the Johansen-Jusilius test presents some drawbacks: (i) it is subject to asymptotic properties, i.e., large sample size since a small sample size would produce unreliable results, and (ii) as noted by (Hall, 1989), the JJ test may be sensitive to the order of autoregressions. (Ibrahim, 2000)

Therefore, when applying the Johansen-Juselius method to the dataset, it is important to note that the results for Portugal's 15 years will not be reliable for the Bear 2 period since the sample size is extremely small.

Since the goal is to understand if interest rate swaps and German bond futures are viable instruments to hedge interest rate risk, cointegration will be tested between swap rates and bond yields, GE yields, and the remaining countries' yields.

3.3.1. COINTEGRATION BETWEEN SWAP RATES AND BOND YIELDS

Table A.2 in the annex presents, for each period, the results of the Engle-Granger test, while tables A.3 and A.4 in the annex present the results of the Johansen-Juselius test, where the orders of cointegration are set alternatively to 4 and 8.

From the Engle-Granger test, the null hypothesis of no cointegration between the swap rates and the bond yields of each country cannot be rejected in most cases. Regardless of the variables used for normalization, the EG test suggests non-cointegration between the variables, except the bull period, which diverges from the rest, more specifically in the short-medium term, where the null hypothesis cannot be accepted in most cases, suggesting cointegration between the variables.

Unlike the previous test, the trace and maximal eigenvalues results from the Johansen-Juselius test cannot accept the null hypothesis, regardless of the order of auto-regression for most of the tenors and periods. The results suggest the existence of cointegration between the variables.

In most cases, the EG test suggests the absence of cointegration between swap rates and bond yields. In contrast, the result of the JJ test suggests the opposite: the existence of cointegration between the variables indicates a long-run relationship between the swap rates and bond yields. Even though the latter test is known to be more powerful than the Engle-Granger test, it is important to note that the Johansen-Juselius test is sensitive to the order of auto-regressions and the lag structures chosen to perform the test were the most common, 4-4 and 8-8.

3.3.2. Cointegration between German yields and Portugal, Spain and Italy yields

Similarly, Tables A.5, A.6, and A.7 present report the results for the cointegration tests between German yields and Portugal, Spain, and Italy yields. Table A.5 presents the results of the Engle-Granger test for each period, while Tables A.6 and A.7 present the results of the Johansen-Juselius test for the orders of cointegration of 4 and 8, respectively.

Much like before, in most cases, the results from the Engle-Granger test cannot reject the null hypothesis of no cointegration between the variables regardless of which variable is used for normalization. Alternatively, the results from the JJ method cannot accept the null hypothesis for both orders of auto-regression for most cases, proposing the existence of cointegration between the variables.

When comparing the results from Table A.2 and Table A.5, both suggest no cointegration between the variables; however, the bull period distinguishes one from the other, as in the first table, the null hypothesis is mostly rejected for the short-medium term.

In sum, the results from both the EG test and the JJ test are similar to those performed previously, with the Engle-Granger test suggesting no cointegration between the yields and the Johansen-Juselius test suggesting the opposite. Moreover, the drawbacks mentioned in the previous subsection regarding the latter test should also be considered.

3.4. GRANGER CAUSALITY TEST

Having established that each series is non-stationary and tested for cointegration, it is important to understand the short-run interactions between the variables using the Granger causality models and integrating the previously obtained results. (Ibrahim, 2000)

To examine whether X Granger causes Y, the null hypothesis of non-causality will be tested. In other words, if lagged x-values do not explain the variation in y, the null hypothesis cannot be rejected, and X_t will not cause Y_t. To test the dataset for Granger causality, it will be performed (i) between swap rates and bond yields and (ii) GE yields and the remaining countries' yields; the variables will be expressed in their first differences since they are non-stationary. The bivariate model can be expressed as,

$$\Delta y_t = c_1 + \sum_{i=1}^{k1} \alpha_i \Delta y_{t-i} + \sum_{i=1}^{k2} \beta_i \Delta yld_{t-i} + \varepsilon_i \quad (3.2)$$

$$\Delta y_t = c_1 + \sum_{i=1}^{k1} \alpha_i \Delta y_{t-i} \quad (3.3)$$

where y is the swap rates in the first case and German bond yields for the second case, and yld corresponds to the bond yields. The reverse causation from yld to y is also going to be tested.

From the equation, the null hypothesis of no causation is not rejected if $\sum \beta = 0$. This test can yield four alternative patterns of causality: (i) unidirectional causality from y to yld, (ii) unidirectional causality from yld y, (iii) bi-directional causality, and (iv) no causality. (Ibrahim, 2000)

To implement the Granger causality test, it is necessary to determine the lag lengths of the right-hand-side variable. According to (Thornton & Batten, 1985), the search for a lag space can be done by either identifying the appropriate lag structure based on some statistical criterion or specifying a few alternative lag structures, the most common being the 4-4 and 8-8. There are several statistical criteria on which the selection of these parameters can be based, which in turn causes different causality test results from the same data.

As has been noted by (Thornton & Batten, 1985), "the typical model selection criteria trade off the bias associated with a parsimonious parametrization against the inefficiency associated with overparameterization." As mentioned previously, there are several criteria for specifying the lag length; for instance, the (Akaike, 1970) final prediction error (FPE) suggested by (Hsiao, 1981) gives more importance to unbiasedness over efficiency; however, it is asymptotically inefficient, resulting in long lags in large samples. As suggested by (Geweke & Meese, 1981), the Bayesian estimation criteria (BEC) is another model for lag length specification. Unlike FPE, for large samples, it selects the correct lag and, hence, is asymptotically efficient.

To test whether there is Granger causality between the variables, the lag structure chosen for both cases will be the most common, 4-4 and 8-8. Tables A.8 and A.9 in the annex present the results of the Granger causality test performed between swap rates and bond yields, and GE yields and the remaining countries' yields, respectively, where green represents significance at the 5% level.

The results from Table A.8 show a higher predominance of Granger causality in the first two periods, Bear 1 and Bull 1, where, in most cases, the null hypothesis of no-causation cannot be accepted, suggesting causality between the variables. In the first period, even though there are cases of bi-directional causality, in most cases, it is unidirectional causality from swaps to bond yields. The same is true for the second period, bull 1, except for more cases of bi-directional causality.

These findings suggest that interest rate swaps might be a valuable instrument to hedge interest rate risk prior to government auctions, at least during the first two periods of the dataset. Furthermore, the results show a decrease in causality over time, especially in the period after the crisis, where the null hypothesis of no-causality is only rejected for a few cases in the short-medium term.

By contrast, Table A.9 presents quite a different result when testing between German yields and Portugal's, Spain's, and Italy's yields. In this case, the null hypothesis of no-causation is most rejected during the Bear 2 period, suggesting bi-directional and both-ways unidirectional causality between the variables, with the former being the most predominant. However, similarly to the previous findings, there is practically no causality between the variables during the post-crisis.

4. EMPIRICAL STUDY

Due to the nature of the debt management agencies' core activities, interest rate risk is an intrinsic factor arising from the necessity of issuing debt and refinancing it over time. Increases in interest rates have a direct impact on borrowing and refinancing strategies.

As previously mentioned, a commonly used strategy to manage this risk is to enter into a swap contract to reduce the duration of the outstanding debt, benefiting from lower costs associated with short-term interest rates.

Assuming the yield curve is comprised of the risk-free rate plus the risk premium, both IR swaps and German bond futures could be viable instruments for debt management agencies to hedge against increases in the risk-free component of the yield. The risk premium, also referred to as the z-spread, remains unhedged.

This strategy allows the issuer to lock the risk-free rate before the auction and protect itself from increases in interest rates.

For this study, transaction costs and margining will not be considered. Furthermore, the pre-hedging strategies will be implemented under the assumption that a single bond line is being issued.

These strategies will be tested in Portuguese, Spanish, and Italian auctions. The data used for Portugal and Italy covers the whole period, from the beginning of 2000 until the end of 2019. However, Spanish data only starts in 2014, as the DMO website only provides auction results as of that year.

4.1. PRE-HEDGING INTEREST RATE RISK WITH INTEREST RATE SWAPS

The first strategy is to pre-hedge interest rate risk using swaps. The goal of this strategy is not to transform a fixed payment into a floating but rather to lock the risk-free rate component of the yield curve and protect against increases in interest rates. Leaving the risk premium component of the yield curve unhedged.

To do so, the bond issuer, the debt management agency for this paper, enters into a swap agreement one week before the auction date. The swap's maturity equals the residual maturity of the bond being auctioned, and the issuer pays the fixed rate and receives the floating rate. The swap was unwound one week later, during the auction day.

The exact amount being issued is not known prior to the auction; however, the interval amount being auctioned is published in the auction announcement. Therefore, the debt manager decides the amount. Nonetheless, the actual amount of the auctions will be considered for this study.

This strategy secures the risk-free rate and enables the swap payer, in this case, the DMO, to be indifferent to increases in interest rates. Assuming an increase in the swap rates, the mark-to-market of the derivative will be positive for the party paying the fixed leg, which in this case would be the DMO. Thus, the debt managers would unwind the swap during the auction day, benefiting from the positive market value.

This strategy was tested for 536 auctions: 75 from Portugal, 87 from Spain, and 374 from Italy. The results are grouped per country, period- defined previously- and residual maturity.

So, the success of using swaps to pre-hedge sovereign auctions can be determined in two steps. The first step is to understand if the risk-free rate was locked successfully. To do so, it is important to compare the swap rate and the country's yield a week prior to the auction and on the auction day. If both moved in the same direction, i.e., increased or decreased, the risk-free rate component was successfully locked.

After establishing in which cases the risk-free rate was locked successfully, the second step is to understand if, for these successful cases, the change in the swap rate is more significant or smaller than the change in the country's yield. This step will give insight into whether the profit from the mark-to-market value of the swap can offset the increase in borrowing costs.

4.2. PRE-HEDGING INTEREST RATE RISK WITH GERMAN BOND FUTURES

The second strategy to be tested is using German bond futures to pre-hedge interest rate risk. Like the previous strategy, the goal is to lock the risk-free rate component of the yield curve and protect against increases in the risk-free rate before the auction date, with the risk premium component of the yield curve left unhedged.

To achieve this, the DMO sells German bond futures one week before the auctions and closes the position during the auction day. To do so, the German Bund future will be used, where the underlying is represented by a basket of deliverable bonds with a residual maturity of 8.5 to 10.5 years at the time of delivery. The number of contracts was adjusted to the amount auctioned.

For simplicity, it will be assumed that the duration of the future is 9 years, and the gain/loss resulting from the strategy will be adjusted to the duration of the bond being auctioned. This strategy will only be tested from 2008 onwards due to the lack of daily quotes prior to this year.

Presuming there is an increase in interest rates, the quote price of the future will decrease. Hence, during the auction day, the debt managers close their position by mirroring the position entered a week earlier, i.e., buying the same future for the same amount, profiting from the price decrease. This gain from the futures will partially offset the increase in borrowing costs of the auction.

This strategy was tested for fewer auctions when compared to the previous strategy: 44 from Portugal, 87 from Spain, and 136 from Italy. The results are grouped per country, period, and residual maturity.

The success parameters of this strategy are equal to those of the previous one. The first step is to assess if the risk-free rate was locked effectively by comparing the yields of the German and the country a week before and on auction day. If both moved in the same direction, the risk-free rate was locked with success.

The second step is to verify for the successful cases whether the change in the German yield exceeds the change in the country's yield. As previously mentioned, the price of the bund future declines when there are increases in the German yield; the more significant the increase is, the bigger the profit of this strategy. This step will provide a deeper understanding of whether the profit from selling and buying bund futures can offset the increase in borrowing costs.

5. RESULTS AND DISCUSSION

The strategies will be analyzed separately. The first strategy will be pre-hedging using swaps, followed by pre-hedging using futures.

Table 5-1 shows the overall success of this strategy for the analyzed countries based on the two-step analysis. It shows, for each country, the total number of swaps entered, how many were successful based on the first step described previously, and lastly, how many of these successful swaps observed an increase in rates and if the increase in the country's yield is smaller than the increase in the swap rate based on the second step aforementioned.

Based on the percentage of success, interest rate swaps are a viable instrument to lock the risk-free rate. Further, when only considering successful cases where the rate change was positive, we can conclude that for most cases, the change in the swap rate is smaller than the change in the country's yield.

One explanation for this could be that most of the change in the country's yield is related to the risk-premium component of the yield curve rather than the risk-free rate component. A contributing factor to the credit spread's movement is the unpredictability of auction announcements. It is known that the debt management agencies will carry auctions throughout the year; however, the dates and frequency are not known. This element of surprise is especially relevant for Portugal and Spain, where the annual auction calendar is not disclosed in advance, further contributing to the volatility in the credit spreads. In contrast, Italy's debt management agency publishes an auction calendar annually, reducing this uncertainty.

Table 5-1- Pre-hedging using swaps overall result

	Nº of Swaps	Successful	Successful (%)	+Δ Rates	Δ Country Rate < Δ Swap Rate	Δ Country Rate < Δ Swap Rate (%)
PT	75	63	84%	27	11	41%
SP	87	65	75%	28	14	50%
IT	374	304	81%	180	85	47%

Similar to Table 5-1, Tables 5-2, 5-3, and 5-4 show the results in greater detail for each country, residual maturity, and period. This helps understand whether there is a maturity or period where the strategy is more successful.

Spain's results are only for the post-crisis period, where the risk-free component is locked successfully for most residual maturities, except the 9Y and 13Y. The worst performance is for the 7Y, 14Y, and 28Y, with a success rate of 50%, 33%, and 33%, respectively. The 10Y and 15Y perform relatively well, with a success rate of 81% and 71%, while the 30Y benchmark underperforms with a success of 50%.

The results for the second parameter of success are for the most tenors unsuccessful, with a minimum success rate of 36% for the 10Y.

The strategy's overall performance for Portugal yields positive results except for the 16Y and 26Y residual maturity, where the strategy was unsuccessful. Only considering the first parameter of success of locking the risk-free rate, the strategy delivers strong results, with the 4Y being less effective. The 5Y, 10Y, 15Y, and 30Y benchmarks perform very well, with a minimum success rate of 73% for the 5Y.

The second parameter of success – change in Portugal's yield vs changes in swap rates – the strategy does not perform well with success rates only for the 5Y, 10Y, and 15Y.

Looking at the results across the different periods rather than the residual maturity[2], the success decreases over time for both success criteria, i.e., Bear 1 performs the best, and post-crisis performs the worst.

For Italy, it is clear that overall, the strategy successfully locks the risk-free rate component for all residual maturities. It is less effective in the 6Y, 7Y, and 14Y, where the success rate was between 60% and 67%. For the benchmarks 5Y, 10Y, 15Y, and 30Y, the success rate is relatively high, above 80%.

Regarding the change in Italy's yield versus the change in the swap rate, the best performance residual maturity is the 14Y, with a success rate of 67%. The benchmarks 10Y and 15Y perform well, with a 58% and 64% success rate, respectively.

Taking an alternative approach and analyzing the results over different periods[3], the bull 1 period performs best with a success rate of 92%, while the post-crisis period underperforms with a success rate of 70%. Moreover, the second parameter of success – changes in Italy's yield vs changes in Swap rates – is the same: the bull 1 period has the best results with a success of 63%. In comparison, the post-crisis period only had a success rate of 24%.

[2] See the appendix for the results presented in the perspective of the period.
[3] See the appendix for the results presented in the perspective of the period.

Table 5-2– Results of pre-hedging using swaps for Spain

Residual Maturity	Period	N of Swaps	Successful	Successful (%)	+Δ Rates	Δ SP Rate < Δ Swap Rate	Δ SP Rate < Δ Swap Rate (%)
7Y	Post-crisis	2	1	50%	1	1	100%
8Y	Post-crisis	4	3	75%	1	0	0%
9Y	Post-crisis	2	0	0%	0	0	
10Y	Post-crisis	37	30	81%	14	5	36%
11Y	Post-crisis	3	3	100%	2	1	50%
12Y	Post-crisis	2	2	100%	1	0	0%
13Y	Post-crisis	1	0	0%	0	0	
14Y	Post-crisis	3	1	33%	0	0	
15Y	Post-crisis	7	5	71%	3	2	67%
16Y	Post-crisis	6	4	67%	1	1	100%
19Y	Post-crisis	1	1	100%	1	1	100%
21Y	Post-crisis	1	1	100%	0	0	
22Y	Post-crisis	1	1	100%	0	0	
23Y	Post-crisis	3	2	67%	0	0	
24Y	Post-crisis	1	1	100%	0	0	
26Y	Post-crisis	1	1	100%	0	0	
27Y	Post-crisis	1	1	100%	1	1	100%
28Y	Post-crisis	3	1	33%	0	0	
29Y	Post-crisis	6	6	100%	2	1	50%
30Y	Post-crisis	2	1	50%	1	1	100%

Table 5-3 - Results of pre-hedging using swaps for Portugal

Residual Maturity	Period	N of Swaps	Successful	Successful (%)	+Δ Rates	Δ PT Rate < Δ Swap Rate	Δ PT Rate < Δ Swap Rate (%)
3Y	Bull 1	6	6	100%	1	0	0%
	Bear 2	1	1	100%	0	0	
		7	7	100%	1	0	0%
4Y	Bull 1	2	1	50%	1	0	0%
	Post-crisis	1	1	100%	1	0	0%
		3	2	67%	2	0	0%
5Y	Bear 1	4	4	100%	3	2	67%
	Bull 1	3	2	67%	1	0	0%
	Bear 2	1	1	100%	0	0	
	Post-crisis	3	1	33%	1	0	0%
		11	8	73%	5	2	40%
6Y	Bull 1	1	1	100%	1	0	0%
	Bear 2	3	3	100%	2	0	0%
		4	4	100%	3	0	0%

Residual Maturity	Period	N of Swaps	Successful	Successful (%)	+Δ Rates	Δ PT Rate < Δ Swap Rate	Δ PT Rate < Δ Swap Rate (%)
7Y	Post-crisis	1	1	100%	0	0	
		1	1	100%	0	0	
10Y	Bear 1	2	2	100%	0	0	
	Bull 1	7	7	100%	5	3	60%
	Bear 2	7	7	100%	3	2	67%
	Post-crisis	18	14	78%	6	3	50%
		34	30	88%	14	8	57%
15Y	Bear 2	3	2	67%	0	0	
	Post-crisis	6	5	83%	1	1	100%
		9	7	78%	1	1	100%
16Y	Post-crisis	1	0	0%	0	0	
		1	0	0%	0	0	
18Y	Post-crisis	1	1	100%	0	0	
		1	1	100%	0	0	
26Y	Post-crisis	1	0	0%	0	0	
		1	0	0%	0	0	
27Y	Post-crisis	1	1	100%	0	0	
		1	1	100%	0	0	
30Y	Bull 1	1	1	100%	0	0	
	Bear 2	1	1	100%	1	0	0%
		2	2	100%	1	0	0%

Table 5-4 - Results of pre-hedging using swaps for Italy

Residual Maturity	Period	N of Swaps	Successful	Successful (%)	+Δ Rates	Δ SP Rate < Δ Swap Rate	Δ SP Rate < Δ Swap Rate (%)
4Y	Bear 1	2	1	50%	1	1	100%
	Bull 1	8	7	88%	3	3	100%
	Bear 2	7	6	86%	4	2	50%
	Post-crisis	3	3	100%	2	0	0%
		20	17	85%	10	6	60%
5Y	Bear 1	36	31	86%	16	8	50%
	Bull 1	34	31	91%	20	13	65%
	Bear 2	14	13	93%	7	0	0%
	Post-crisis	19	13	68%	7	1	14%
		103	88	85%	50	22	44%
6Y	Bear 1	3	2	67%	0	0	
	Bear 2	2	2	100%	2	1	50%
	Post-crisis	10	6	60%	3	1	33%
		15	10	67%	5	2	40%
7Y	Post-crisis	18	11	61%	7	3	43%

Residual Maturity	Period	N of Swaps	Successful	Successful (%)	+Δ Rates	Δ SP Rate < Δ Swap Rate	Δ SP Rate < Δ Swap Rate (%)
		18	11	61%	7	3	43%
8Y	Post-crisis	1	1	100%	1	0	0%
		1	1	100%	1	0	0%
9Y	Bear 1	3	3	100%	1	0	0%
	Bull 1	1	1	100%	1	0	0%
	Post-crisis	1	1	100%	0	0	
		5	5	100%	2	0	0%
10Y	Bear 1	23	19	83%	10	7	70%
	Bull 1	40	38	95%	21	13	62%
	Bear 2	11	8	73%	5	3	60%
	Post-crisis	23	16	70%	9	3	33%
		97	81	84%	45	26	58%
11Y	Bear 1	7	5	71%	2	1	50%
	Bull 1	5	5	100%	2	1	50%
	Bear 2	7	4	57%	2	1	50%
	Post-crisis	1	0	0%	0	0	
		20	14	70%	6	3	50%
12Y	Bear 2	1	0	0%	0	0	
		1	0	0%	0	0	
14Y	Bull 1	4	3	75%	3	2	67%
	Bear 2	1	0	0%	0	0	
		5	3	60%	3	2	67%
15Y	Bear 1	5	5	100%	3	3	100%
	Bull 1	9	8	89%	4	3	75%
	Bear 2	3	3	100%	2	1	50%
	Post-crisis	4	3	75%	2	0	0%
		21	19	90%	11	7	64%
16Y	Bull 1	4	3	75%	3	1	33%
	Post-crisis	3	2	67%	1	0	0%
		7	5	71%	4	1	25%
19Y	Post-crisis	1	1	100%	1	0	0%
		1	1	100%	1	0	0%
20Y	Bear 2	2	1	50%	1	0	0%
		2	1	50%	1	0	0%
28Y	Post-crisis	2	2	100%	2	0	0%
		2	2	100%	2	0	0%
29Y	Bear 1	2	2	100%	2	1	50%
	Bear 2	1	0	0%	0	0	
	Post-crisis	2	2	100%	1	0	0%
		5	4	80%	3	1	33%
30Y	Bear 1	25	20	80%	13	5	38%
	Bull 1	11	11	100%	6	4	67%
	Bear 2	6	4	67%	4	1	25%
	Post-crisis	9	7	78%	6	2	33%
		51	42	82%	29	12	41%

The second strategy tested was to pre-hedge auctions using the German bund future. Table 5.5 shows this strategy's overall success results based on the previously mentioned steps. Maintaining the same structure used for the previous strategy, it shows, for each country, the total number of futures, how many were successful, and for those cases, how many experienced an increase in rates and if the increase in the country's yield was smaller than the increase in the German yield.

Based on the general percentage of success, the German bund future appears viable for locking the risk-free rate for Portugal and perhaps Spain. Italy's success rate is relatively lower, suggesting this strategy may not be appropriate for pre-hedging auctions. A potential explanation for such differences among the studied countries could be the sample size; Portugal's and Spain's data sample for this strategy is much smaller than Italy's.

Moreover, for the cases where the risk-free was locked successfully, and there was an increase in rates, all countries yielded similar success results; the change in German yields is generally smaller than in the country's yield.

The effect of auction announcements stated previously is also applicable to this strategy: Portugal and Spain's credit spreads tend to be more sensitive to auction announcements.

Even though, for this paper, the German yield is considered risk-free, it also has a credit spread component. Currently, Germany has a very high credit rating (S&P AAA), which allows the possibility of the bund future being used as an instrument for pre-hedging auctions. However, in the event of a credit downgrade, this strategy might become obsolete as the risk-premium component of the German yield increases and can no longer be considered risk-free.

Table 5-5 - Pre-hedging using futures overall result

	N of Futures	Successful	Success (%)	+Δ Rates	Δ Country Rate < Δ GE Rate	Δ Country Rate < Δ GE Rate (%)
PT	44	39	89%	15	7	47%
SP	87	66	76%	30	12	40%
IT	136	87	64%	47	19	40%

Tables 5-6, 5-7, and 5-8 show the results for each country, residual maturity, and period. This gives insight into whether there is a period or maturity where this strategy is more suitable.

Spain's overall results are relatively successful for locking the risk-free rate, except for the 26Y. The worst performance is for the 7Y, 14Y, 29Y and 30Y, with a success rate of 33%, 50%, 50% and 50%, respectively. The benchmarks 10Y and 15Y perform well, with a minimum success of 81%. The results fell short for the second tested parameter , with only a few successful tenors.

Portugal’s results for the first parameter are slightly more successful than Spain’s. The benchmark 5Y has the worst performance, with a success rate of 50%, while the remaining tenors have a minimum success rate of 86%. As for the second parameter, the results are similar to those of Spain, with most tenors being unsuccessful.

Italy's results are less successful than those of Portugal and Spain. Most tenors successfully lock the risk-free rate, except for 12Y, 14Y, 19Y and 20Y. The 10Y benchmark performs better than the 5Y and 30Y benchmarks, with a success rate of 77%, whereas the other two have a success rate of 68% and 54%, respectively. Much like Portugal and Spain, the results are not as successful as desired for the second parameter.

Table 5-6 - Results of pre-hedging using futures for Spain

Residual Maturity	Period	N of Futures	Successful	Successful (%)	+Δ Rates	Δ SP Rate < Δ GE Rate	Δ SP Rate < Δ GE Rate (%)
7Y	Post-crisis	2	1	50%	1	1	100%
8Y	Post-crisis	4	3	75%	1	0	0%
9Y	Post-crisis	2	1	50%	1	0	0%
10Y	Post-crisis	37	30	81%	14	5	36%
11Y	Post-crisis	3	2	67%	1	1	100%
12Y	Post-crisis	2	1	50%	0	0	
13Y	Post-crisis	1	1	100%	1	0	0%
14Y	Post-crisis	3	1	33%	0	0	
15Y	Post-crisis	7	7	100%	4	2	50%
16Y	Post-crisis	6	6	100%	2	1	50%
19Y	Post-crisis	1	1	100%	1	1	100%
21Y	Post-crisis	1	1	100%	0	0	
22Y	Post-crisis	1	1	100%	0	0	
23Y	Post-crisis	3	2	67%	0	0	
24Y	Post-crisis	1	1	100%	0	0	
26Y	Post-crisis	1	0	0%	0	0	
27Y	Post-crisis	1	1	100%	1	1	100%
28Y	Post-crisis	3	2	67%	1	0	0%
29Y	Post-crisis	6	3	50%	1	0	0%
30Y	Post-crisis	2	1	50%	1	0	0%

Table 5-7 - Results of pre-hedging using futures for Portugal

Residual Maturity	Period	N of Futures	Successful	Successful (%)	+Δ Rates	Δ PT Rate < Δ GE Rate	Δ PT Rate < Δ GE Rate (%)
4Y	Post-crisis	1	1	100%	1	0	0%
		1	1	100%	1	0	0%
5Y	Bear 2	1	1	100%	0	0	
	Post-crisis	3	1	33%	1	1	100%
		4	2	50%	1	1	100%
6Y	Bear 2	2	2	100%	1	0	0%
		2	2	100%	1	0	0%
7Y	Post-crisis	1	1	100%	0	0	
		1	1	100%	0	0	
10Y	Bear 2	4	4	100%	2	2	100%
	Post-crisis	18	15	83%	7	3	43%
		22	19	86%	9	5	56%
15Y	Bear 2	3	3	100%	0	0	
	Post-crisis	6	6	100%	1	0	0%
		9	9	100%	1	0	0%
16Y	Post-crisis	1	1	100%	1	1	100%
		1	1	100%	1	1	100%
18Y	Post-crisis	1	1	100%	0	0	
		1	1	100%	0	0	
26Y	Post-crisis	1	1	100%	1	0	0%
		1	1	100%	1	0	0%
27Y	Post-crisis	1	1	100%	0	0	
		1	1	100%	0	0	
29Y	Bear 2	1	1	100%	0	0	
		1	1	100%	0	0	

Table 5-8 - Results of pre-hedging using futures for Italy

Period	Residual Maturity	N of Futures	Successful	Successful (%)	+Δ Rates	Δ IT Rate < Δ GE Rate	Δ IT Rate < Δ GE Rate (%)
4Y	Bear 2	5	3	60%	2	2	100%
	Post-crisis	3	2	67%	1	0	0%
		8	5	63%	3	2	67%
5Y	Bear 2	9	6	67%	5	2	40%
	Post-crisis	19	13	68%	4	0	0%
		28	19	68%	9	2	22%
6Y	Bear 2	2	1	50%	1	1	100%
	Post-crisis	10	6	60%	3	1	33%
		12	7	58%	4	2	50%
7Y	Post-crisis	18	9	50%	4	3	75%
		18	9	50%	4	3	75%
8Y	Post-crisis	1	1	100%	1	0	0%
		1	1	100%	1	0	0%
9Y	Post-crisis	1	1	100%	0	0	
		1	1	100%	0	0	
10Y	Bear 2	8	7	88%	3	1	33%
	Post-crisis	23	17	74%	8	3	38%
		31	24	77%	11	4	36%
11Y	Bear 2	3	0	0%	0	0	
	Post-crisis	1	1	100%	1	0	0%
		4	1	25%	1	0	0%
12Y	Bear 2	1	0	0%	0	0	
		1	0	0%	0	0	
14Y	Bear 2	1	0	0%	0	0	
		1	0	0%	0	0	
15Y	Bear 2	3	3	100%	2	1	50%
	Post-crisis	4	3	75%	2	1	50%
		7	6	86%	4	2	50%
16Y	Post-crisis	3	3	100%	1	1	100%
		3	3	100%	1	1	100%
19Y	Post-crisis	1	0	0%	0	0	
		1	0	0%	0	0	
20Y	Bear 2	2	0	0%	0	0	
		2	0	0%	0	0	
28Y	Post-crisis	2	2	100%	2	1	50%
		2	2	100%	2	1	50%
29Y	Bear 2	1	0	0%	0	0	
		1	0	0%	0	0	
29Y	Post-crisis	2	2	100%	1	1	100%
		2	2	100%	1	1	100%
30Y	Bear 2	4	2	50%	2	0	0%
	Post-crisis	9	5	56%	4	1	25%
		13	7	54%	6	1	17%

6. CONCLUSIONS AND FUTURE RESEARCH

Since the turn of the century, significant developments and transformations have occurred in the European bond market. The introduction of the euro created one of the biggest markets for sovereign issuance, with bonds being more homogeneous regarding their financial characteristics and creditworthiness. It also allowed debt management agencies to include more non-resident banks in their primary dealers group.

Similarly, the interest rate swap market has grown exponentially and is now one of the largest segments of the over-the-counter derivatives market. The introduction of the single currency contributed to this growth due to the need for a single and well-defined benchmark.

Debt management agencies are responsible for issuing fixed-income securities as a way for the government to raise capital to finance budget needs. Due to the nature of their business, one of the risks they are directly exposed to is interest rate risk. One common strategy to hedge this risk is using swaps to reduce the portfolio's duration and benefit from the lower short-term interest rates.

This study proposes two strategies to pre-hedge interest rate risk around auction dates. To do so, we tested whether interest rate swaps and German bond futures are viable instruments to hedge against increases in the risk-free rate component of the yield curve.

The results suggest that interest rate swaps are more successful in locking the risk-free rate for the countries under scope. The German bund future mainly succeeded for Portugal and Spain, despite Spain’s results being relatively smaller. The results of Italy suggest that the German bund future is not always suitable, with interest rate swaps yielding better results in locking the risk-free rate.

An explanation of why the swap strategy performs better than the bund future strategy could be that the latter strategy also reflects the credit spread of Germany, thus not always representing the risk-free rate. In contrast, the swap rate does not have this spread. Additionally, there is the possibility of the implicit rate of the futures contract being different from the risk-free rate since it can also reflect additional costs associated with the underlying assets, which in this case would be the bonds eligible for delivery.

When comparing the changes in the swap rates vs. the countries’ yields and the German yield vs. the countries’ yields, both strategies have similar results: most of the time, the countries’ yields have a more significant movement than the benchmarks. A contributing factor to this is the sensitivity of the credit spreads to auction announcements, especially for Portugal and Pain, where auction calendars are published annually like in Italy.

There is a gap in the literature regarding pre-hedging interest rate risk. This study tried to explain the effectiveness of two vanilla instruments to hedge against increases in the risk-free rate component of the yield curve. It could be interesting to understand what other financial instruments and strategies can be used to pre-hedge increases in interest rates around auction dates.

Furthermore, it may be interesting to understand the liquidity, regulatory, and operational implications of entering these derivatives for future investigations.

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APPENDIX A

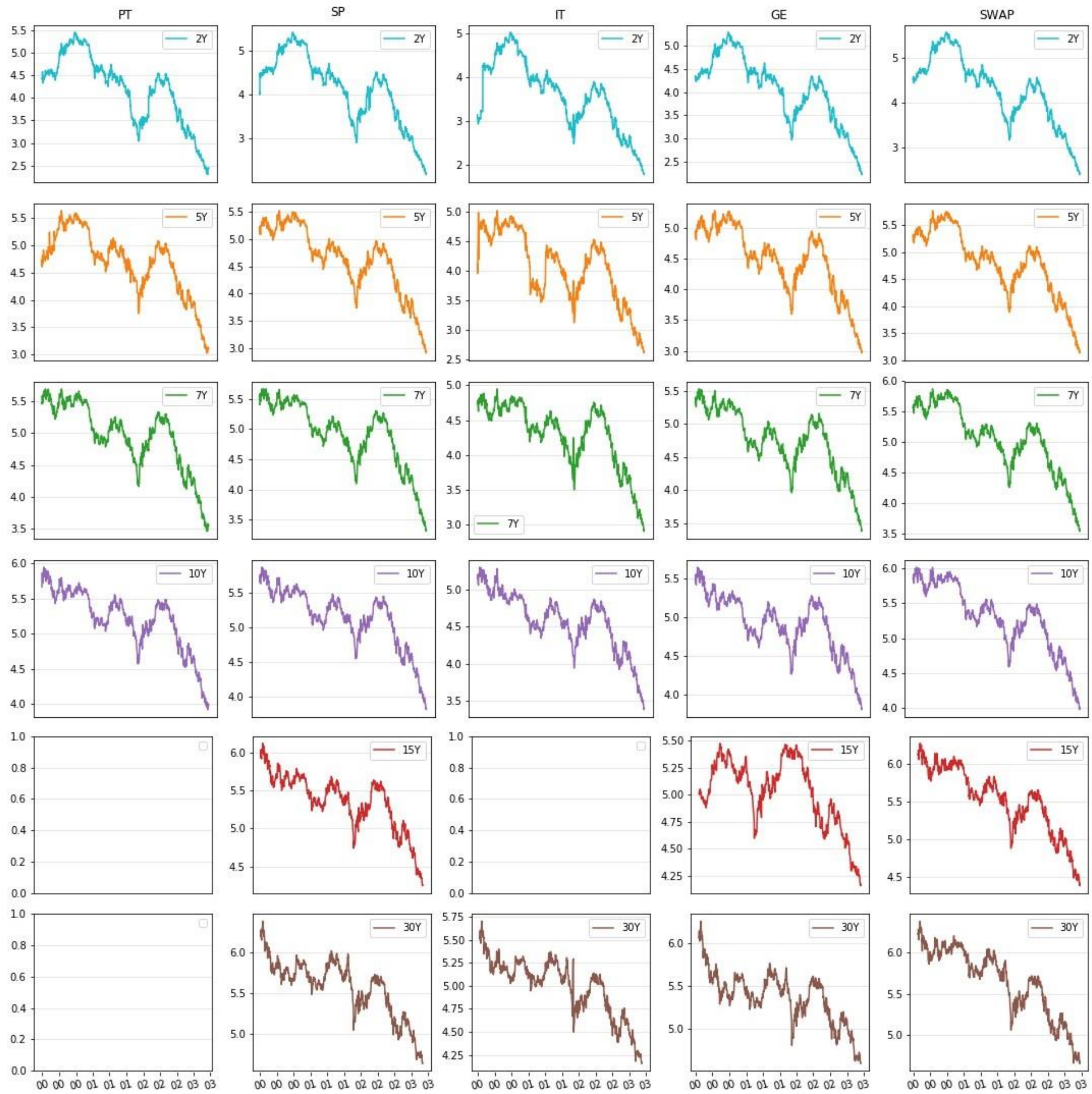

Figure A. 1 - Bear 1 – March 6, 2000, to March 11, 2003

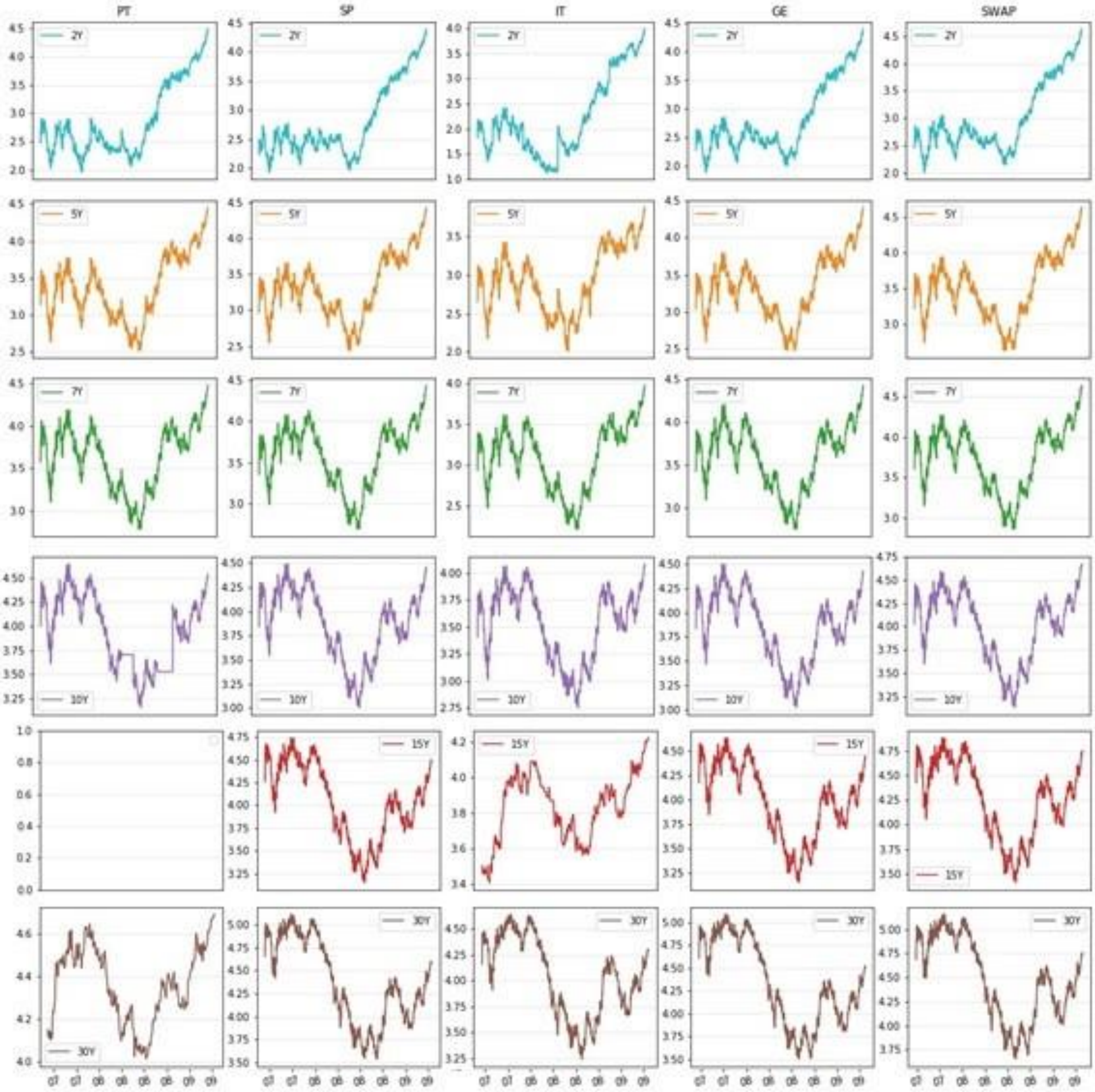

Figure A. 2 - March 12, 2003, to May 31, 2007

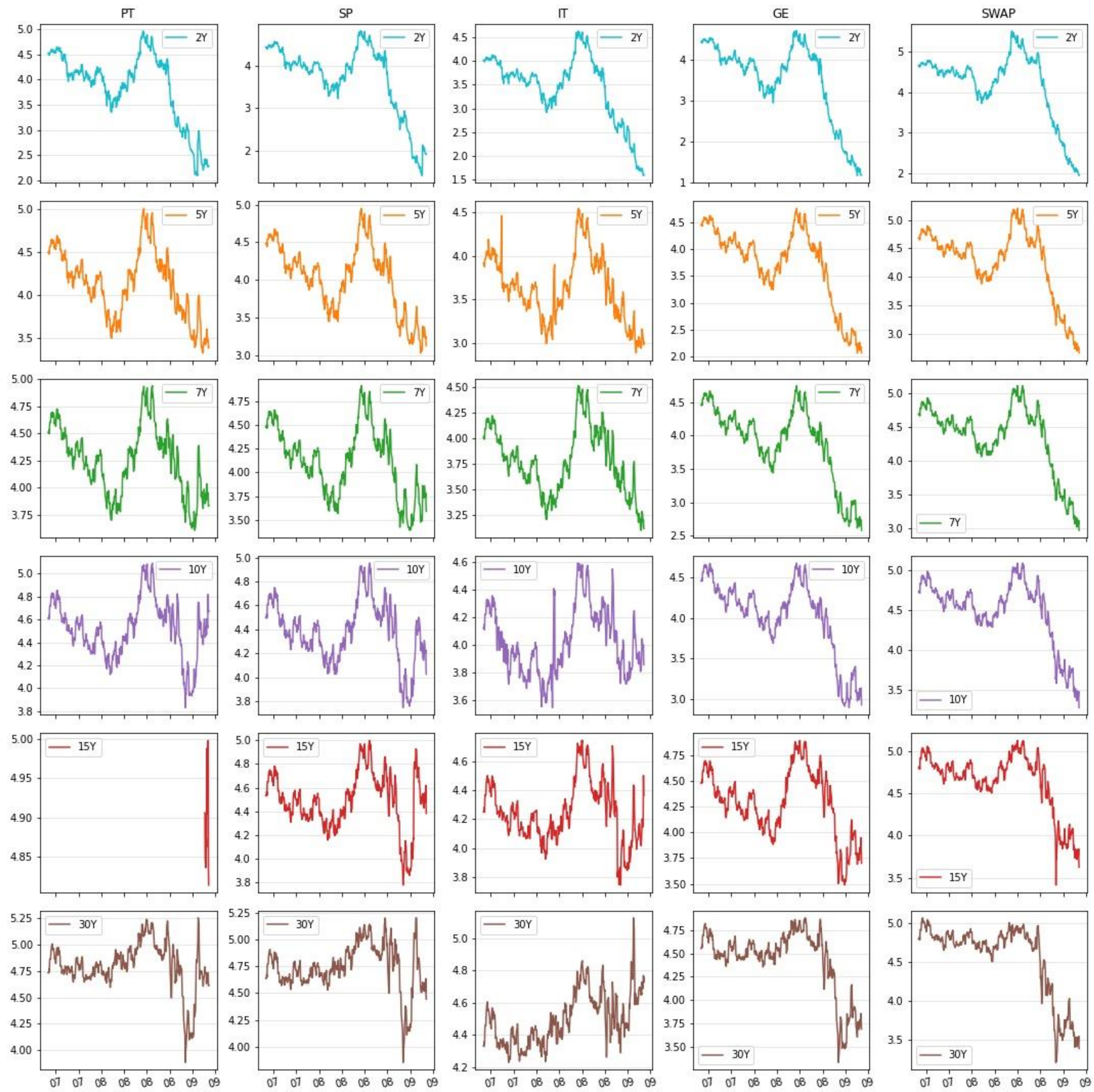

Figure A. 3 - Bear 2 – June 1, 2007, to March 8, 2009

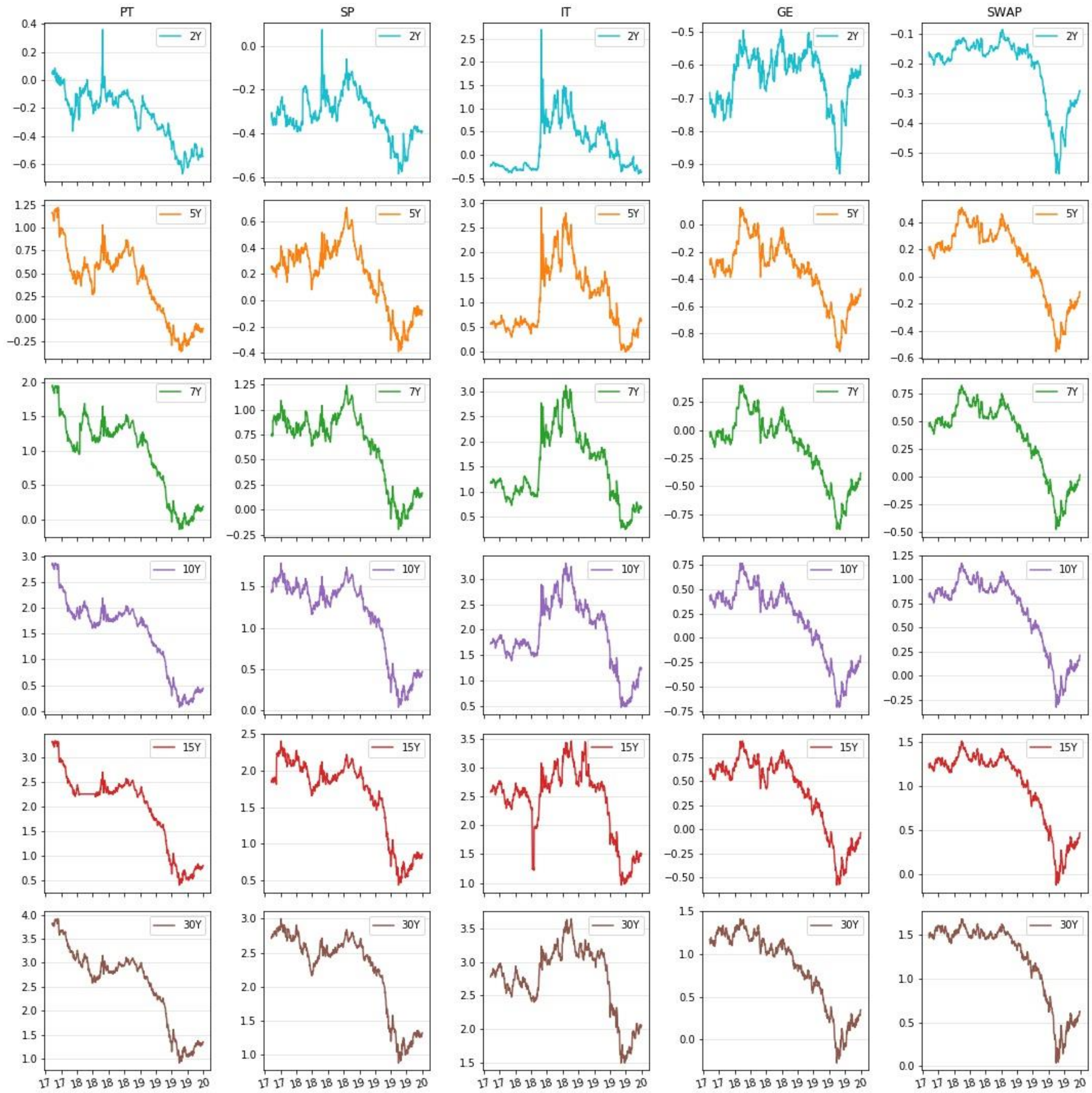

Figure A. 4 - – August 9, 2017, to December 31, 2019

Table A. 1 - Unit Root Tests

ADF Tests									
		Log-Levels				First Log-Differences			
Tenor	Curve	Bear 1	Bull 1	Bear 2	Post-Crisis	Bear 1	Bull 1	Bear 2	Post-Crisis
2Y	*Swap*	1.347	-0.032	2.865	-1.560	-26.108*	-11.033*	-13.101*	-12.357*
	PT	0.821	-0.093	-0.032	-1.336	-27.571*	-24.152*	-21.208*	-15.595*
	SP	0.908	-0.209	-0.094	-1.676	-13.268*	-10.843*	-19.625*	-14.051*
	IT	1.312	-0.663	1.161	-1.308	-11.021*	-32.914*	-12.372*	-16.894*
	GE	1.128	-0.048	1.971	-2.374	-16.774*	-11.015*	-21.046*	-26.170*
5Y	*Swap*	1.055	-0.878	1.223	-0.849	-30.141*	-24.402*	-13.812*	-16.104*
	PT	0.968	-0.805	-1.686	-1.224	-6.237*	-24.105*	-13.337*	-23.708*
	SP	0.981	-0.926	-0.958	-1.272	-26.791*	-32.320*	-20.757*	-12.600*
	IT	-0.027	-1.308	-1.159	-1.464	-19.506*	-33.105*	-10.621*	-15.544*
	GE	0.494	-0.893	0.647	-1.808	-13.837*	-32.413*	-20.479*	-26.073*
7Y	*Swap*	1.151	-1.029	0.899	-1.138	-17.458*	-24.463*	-20.879*	-16.358*
	PT	0.392	-1.052	-2.300	-0.889	-28.556*	-23.751*	-13.075*	-15.701*
	SP	1.372	-1.085	-1.666	-0.804	-17.644*	-32.418*	-20.846*	-15.172*
	IT	1.282	-1.030	-1.416	-1.079	-20.892*	-32.988*	-19.780*	-11.139*
	GE	0.574	-1.086	0.031	-1.586	-17.251*	-32.579*	-19.982*	-25.514*
10Y	*Swap*	0.698	-1.186	0.523	-0.986	-17.575*	-24.531*	-20.795*	-24.785*
	PT	0.525	-1.468	-2.526	-0.714	-17.613*	-33.706*	-9.164*	-14.234*
	SP	0.898	-1.214	-2.130	-0.542	-17.524*	-32.929*	-20.033*	-15.181*
	IT	0.648	-1.426	-2.074	-1.000	-18.286*	-33.490*	-11.415*	-24.533*
	GE	0.046	-1.280	-0.365	-1.218	-17.163*	-33.037*	-19.275*	-25.611*
15Y	*Swap*	0.462	-1.296	0.475	-0.895	-14.621*	-24.841*	-10.904*	-6.840*
	PT	-	-	-2.060	-0.569	-	-	0.000	-15.410*
	SP	0.203	-1.353	-1.745	-0.351	-17.339*	-34.039*	-8.024*	-15.150*
	IT	-	-1.282	-3.082**	-0.900	-	-12.931*	-10.011*	-11.148*
	GE	0.070	-3.072**	-0.129	-1.072	-22.398*	-6.172*	-10.216*	-25.957*
30Y	*Swap*	-0.034	-1.292	-0.057	-0.791	-16.068*	-24.775*	-10.083*	-6.750*
	PT	-	-1.220	-3.097**	-0.472	-	-17.345*	-17.387*	-14.752*
	SP	-0.269	-1.254	-3.313**	-0.246	-15.586*	-34.307*	-16.993*	-14.745*
	IT	-0.018	-1.288	-2.688***	-0.771	-15.343*	-33.553*	-10.311*	-23.880*
	GE	-1.109	-1.231	-1.460	-0.964	-17.274*	-33.909*	-17.732*	-26.634*

Note: *, **, *** indicate significance at 1%, 5% and 10% levels respectively.

Table A. 2 - - Engle-Granger Cointegration Test

Engle-Granger Test									
Tenor		Norm. Variables = Swap Rates				Norm. Variables = Bond Yields			
		Bear 1	Bull 1	Bear 2	Post-Crisis	Bear 1	Bull 1	Bear 2	Post-Crisis
2Y	*PT*	-2.992	-3.091***	-3.054***	-2.938	-3.072***	-3.097***	-3.374**	-3.259***
	SP	-2.455	-3.499**	-2.556	-2.701	-2.482	-3.514**	-2.861	-3.183***
	IT	-4.08*	-2.086	-2.741	-1.48	-4.166*	-2.272	-2.873	-1.996
	GE	-4.827*	-5.422*	-1.727	-1.561	-4.832*	-5.424*	-2.028	-2.444
5Y	*PT*	-4.657*	-2.523	2.195	-2.532	-4.51*	-2.601	-3.124***	-2.982
	SP	-3.165***	-3.419**	1.994	-3.145***	-3.182***	-3.456**	-2.635	-3.276***
	IT	-2.308	-2.966	1.11	-1.249	-2.786	-3.182***	-2.251	-1.66
	GE	-2.843	-4.955*	1.851	-2.517	-2.928	-5.003*	-2.141	-2.786
7Y	*PT*	-2.311	-3.007	-1.184	-3.157***	-2.425	-3.134***	-2.841	-3.42**
	SP	-1.793	-3.177***	0.099	-2.757	-1.708	-3.252***	-2.448	-2.8
	IT	-2.006	-3.139***	-0.197	-1.222	-1.904	-3.168***	-2.51	-1.546
	GE	-2.244	-3.019	-1.873	-2.087	-2.366	-3.096***	-2.204	-2.235
10Y	*PT*	-1.271	-2.225	3.214	-3.016	-1.218	-2.408	-1.38	-3.414**
	SP	-1.038	-1.478	-0.226	-2.73	-0.817	-1.599	-2.056	-2.724
	IT	-1.686	-3	0.343	-1.431	-1.64	-3.098***	-1.947	-1.751
	GE	-1.971	-1.162	-1.635	-2.019	-2.123	-1.383	-2.013	-2.156
15Y	*PT*	-	-	-1.039	-3.231***	-	-	-1.486	-3.5**
	SP	-1.425	-1.323	0.465	-3.011	-1.344	-1.358	-2.426	-2.968
	IT	-	-0.332	1.181	-2.18	-	-0.68	-2.777	-2.093
	GE	-3.107***	-2.522	-0.884	-3.678**	-2.623	-2.593	-1.682	-3.746**
30Y	*PT*	-	-0.87	-0.134	-2.819	-	-1.062	-2.607	-3.186***
	SP	-1.576	-1.172	-0.332	-2.647	-2.124	-1.186	-3.302***	-2.593
	IT	-2.581	-1.892	-1.307	-1.575	-2.588	-1.885	-3.017	-1.707
	GE	-2.129	-0.656	-1.752	-0.914	-2.616	-0.613	-2.486	-1.039

Note: *, **, and *** indicate significance at 1%, 5%, and 10% levels, respectively.

Table A. 3 - Johansen-Juselius Cointegration Test for an order of auto-regression of 4

Johansen-Juselius Test									
Lags = 4									
Tenor	Curve	Bear 1		Bull 1		Bear 2		Post-Crisis	
		Trace	Eigen	Trace	Eigen	Trace	Eigen	Trace	Eigen
2Y	*PT*	10.826*	10.298*	11.62*	11.343*	19.459***	18.842	12.257*	11.262*
	SP	28.73	28.41	13.666**	13.129**	11.381*	11.202*	18.07***	16.977***
	IT	24.194	24.169	5.809*	5.263*	11.137*	10.177*	9.701*	7.283*
	GE	29.269	29.1	29.017	28.51	10.668*	10.51*	9.323*	8.662*
5Y	*PT*	21.06	20.639	7.375*	7.268*	11.883*	11.114*	9.922*	9.445*
	SP	14.352**	13.914**	16.518***	16.015***	12.036*	11.642*	10.658*	10.165*
	IT	8.563*	8.025*	11.729*	11.532*	10.379*	9.547*	10.482*	8.154*
	GE	14.038**	13.726**	23.132	23.075	11.595*	10.521*	12.573*	12.268*
7Y	*PT*	8.428*	8.302*	10.945*	10.459*	9.615*	8.229*	13.817**	13.503**
	SP	4.395*	3.943*	10.305*	9.715*	9.627*	9.188*	8.479*	8.126*
	IT	8.447*	7.993*	14.868**	14.23**	5.809*	5.426*	11.257*	8.234*
	GE	8.398*	7.681*	9.868*	9.503*	10.611*	10.19*	15.701***	14.693***
10Y	*PT*	4.066*	3.906*	11.002*	8.877*	12.293*	9.784*	14.448**	14.2**
	SP	1.932*	1.779*	5.286*	4.167*	8.176*	6.925*	6.865*	6.712*
	IT	5.101*	4.963*	12.798*	11.297*	8.987*	8.237*	11.575*	9.298*
	GE	6.737*	6.344*	7.589*	6.474*	8.083*	7.706*	15.966***	14.607***
15Y	*PT*	-	-	-	-	32.078	31.401	13.903**	13.678**
	SP	2.813*	2.803*	4.5*	2.559*	8.137*	8.131*	7.631*	7.541*
	IT	-	-	4.903*	4.267*	8.525*	8.451*	13.858**	12.67**
	GE	10.919*	10.368*	9.052*	7.583*	4.892*	4.891*	19.051***	18.503***
30Y	*PT*	-	-	5.842*	4.747*	10.846*	9.758*	9.643*	9.367*
	SP	4.264*	3.845*	6.923*	4.702*	11.402*	11.256*	6.313*	6.258*
	IT	18.165***	18.041***	10.292*	8.261*	13.311*	11.748*	10.488*	8.594*
	GE	6.837*	6.834*	5.733*	3.044*	7.597*	7.587*	9.827*	7.275*

Note: *, **, *** indicate significance at 1%, 5% and 10% levels respectively.

Table A. 4 - Johansen-Juselius Cointegration Test for an order of auto-regression of 8

Johansen-Juselius Test									
Lags = 8									
Tenor	Curve	Bear 1		Bull 1		Bear 2		Post-Crisis	
		Trace	Eigen	Trace	Eigen	Trace	Eigen	Trace	Eigen
2Y	*PT*	10.988*	10.684*	11.803*	11.571*	16.213***	16.174***	11.353*	10.362*
	SP	17.113***	16.862***	15.484**	15.017***	12.77*	12.746**	14.212**	13.027**
	IT	24.299	24.238	5.571*	5.053*	9.199*	9.022*	9.806*	7.893*
	GE	22.293	22.236	25.906	25.346	10.943*	10.205*	8.672*	8.147*
5Y	*PT*	21.332	20.629	7.395*	7.231*	9.676*	9.177*	9.082*	8.787*
	SP	9.323*	8.984*	15.239**	14.962***	12.782*	12.58**	7.904*	7.57*
	IT	7.753*	7.389*	8.557*	8.454*	6.187*	5.514*	12.378*	10.801*
	GE	14.782**	14.626***	24.498	24.455	11.967*	10.014*	13.011*	12.822**
7Y	*PT*	6.727*	6.585*	11.457*	10.763*	8.16*	6.564*	13.079*	12.874**
	SP	3.387*	2.954*	10.675*	9.894*	9.597*	8.768*	7.971*	7.765*
	IT	5.562*	5.124*	8.874*	8.023*	5.569*	5.033*	12.156*	10.465*
	GE	8.737*	8.056*	10.194*	9.438*	10.597*	9.998*	18.336***	17.595***
10Y	*PT*	2.509*	2.317*	11.275*	8.798*	13.075*	10.437*	13.687**	13.525**
	SP	1.51*	1.43*	5.595*	4.146*	10.297*	7.539*	7.598*	7.508*
	IT	4.971*	4.831*	12.535*	10.698*	6.658*	4.708*	12.446*	11.121*
	GE	7.422*	6.928*	6.978*	5.941*	8.54*	8.529*	17.769***	16.53***
15Y	*PT*	-	-	-	-	9.604*	9.098*	12.65*	12.518**
	SP	2.077*	2.077*	4.722*	2.727*	10.333*	8.964*	7.522*	7.436*
	IT	-	-	4.188*	3.607*	7.799*	5.502*	13.935**	13.058**
	GE	13.782**	13.244**	9.872*	8.177*	5.986*	4.913*	22.247	21.812
30Y	*PT*	-	-	6.855*	5.568*	11.62*	9.838*	9.383*	9.137*
	SP	3.807*	3.369*	7.32*	4.733*	13.176*	12.177*	6.405*	6.352*
	IT	9.349*	9.321*	8.715*	6.446*	11.084*	8.107*	11.134*	9.818*
	GE	6.521*	6.484*	6.443*	3.398*	7.831*	7.712*	11.14*	8.608*

Note: *, **, *** indicate significance at 1%, 5% and 10% levels respectively.

Table A. 5 - Engle-Granger Cointegration Test

		Engle-Granger Test							
		Norm. Variables = Germany Yields				Norm. Variables = Bond Yields			
Tenor		Bear 1	Bull 1	Bear 2	Post-Crisis	Bear 1	Bull 1	Bear 2	Post-Crisis
2Y	*PT*	-3.861**	3.728	-4.943*	-2.546	-3.912*	-3.721**	-5.08*	-2.15
	SP	-2.755	4.235	-3.351**	-3.492	-2.79	-4.239*	-3.047	-2.741
	IT	-2.953	2.382	-2.697	-2.636	-3.047	-2.53	-2.661	-2.011
5Y	*PT*	-4.322*	-2.761	-1.058	-2.501	-2.795	-2.768	-1.876	-2.674
	SP	-2.383	-3.024	-1.416	-2.97	-2.283	-2.99	-2.662	-2.856
	IT	-2.939	-2.553	-1.323	-1.695***	-3.105***	-2.761	-2.032	-1.652
7Y	*PT*	-3.304***	-3.174***	0.141	-2.98	-3.302***	-3.181***	-1.626	-3.097***
	SP	-2.794	-3.226***	-0.115	-2.436	-2.642	-3.225***	-2.365	-2.331
	IT	-3.002	-1.863	-0.8	-1.435***	-2.821	-1.824	-2.137	-1.476
10Y	*PT*	-2.326	-2.589	2.073	-2.874	-2.212	-2.682	-1.221	-3.032
	SP	-2.173	-3.899**	-0.267	-2.625	-1.813	-3.877**	-2.182	-2.504
	IT	-2.812	-2.184	-0.175	-1.527	-2.629	-2.086	-1.994	-1.631
15Y	*PT*	-	-	-3.43***	-2.922	-	-	-1.46	-3.046
	SP	-3.101***	-2.133	-1.464	-3.089	-3.116***	-2.076	-3.318***	-2.966
	IT	-	-0.486	-0.976	-2.231	-	-1.029	-3.595**	-2.096
30Y	*PT*	-	0.111	-0.63	-2.63	-	-0.159	-2.594	-2.667
	SP	-3.044	-1.669	-1.076	-2.046***	-2.693	-1.689	-3.273***	-1.862
	IT	-3.546**	-0.982	-1.296	-1.393	-3.182***	-1.155	-2.618	-1.376

Note: *, **, *** indicate significance at 1%, 5% and 10% levels respectively.

Table A. 6 - Johansen-Juselius Cointegration Test for an order of auto-regression of 4

Johansen-Juselius Test									
Lags = 4									
Tenor	Curve	Bear 1		Bull 1		Bear 2		Post-Crisis	
		Trace	Eigen	Trace	Eigen	Trace	Eigen	Trace	Eigen
2Y	*PT*	13.664**	13.552**	15.794***	15.466***	25.387	24.459	9.601*	7.057*
	SP	45.655	45.617	19.133***	18.592	14.268**	13.69**	17.533***	13.473**
	IT	19.714***	19.657	5.888*	5.243*	7.913*	7.478*	12.457*	7.976*
5Y	*PT*	23.707	23.669	7.646*	7.367*	8.995*	8.896*	12.649*	11.225*
	SP	8.983*	8.912*	14.396**	13.9**	8.195*	7.951*	10.856*	9.654*
	IT	11.828*	11.828*	10.498*	9.991*	7.75*	7.731*	11.667*	8.275*
7Y	*PT*	10.276*	10.275*	11.884*	10.815*	7.314*	7.108*	16.568***	15.728***
	SP	11.81*	10.08*	11.365*	10.324*	6.577*	6.395*	9.054*	8.106*
	IT	14.446**	14.36***	7.733*	6.941*	4.962*	4.725*	12.485*	8.732*
10Y	*PT*	6.525*	6.093*	11.861*	9.619*	7.748*	6.771*	15.748***	15.152***
	SP	11.265*	8.753*	16.452***	14.562***	6.596*	6.421*	8.189*	7.69*
	IT	10.712*	10.661*	9.268*	6.423*	8.011*	7.967*	11.7*	8.769*
15Y	*PT*	-	-	-	-	24.045	23.453	15.5***	15.091***
	SP	10.687*	10.682*	6.374*	5.137*	11.399*	9.895*	10.107*	9.852*
	IT	-	-	3.996*	3.594*	15.228**	14.176**	13.722**	11.99*
30Y	*PT*	-	-	6.149*	5.414*	10.763*	10.658*	9.278*	8.937*
	SP	10.085*	9.773*	7.95*	5.496*	13.012*	12.795**	5.381*	4.992*
	IT	21.484	20.987	6.088*	3.842*	11.631*	11.383*	9.664*	6.777*

Note: *, **, *** indicate significance at 1%, 5% and 10% levels respectively.

Table A. 7 - Johansen-Juselius Cointegration Test for an order of auto-regression of 8

Johansen-Juselius Test									
Lags = 8									
Tenor	Norm. Variables	Bear 1		Bull 1		Bear 2		Post-Crisis	
		Trace	Eigen	Trace	Eigen	Trace	Eigen	Trace	Eigen
2Y	*PT*	12.595*	12.466**	13.178*	12.92**	19.85***	19.063	9.693*	7.279*
	SP	31.28	31.213	16.783***	16.281***	17.696***	17.168***	14.183**	10.506*
	IT	19.677***	19.26	5.512*	4.965*	4.959*	4.592*	13.37*	9.282*
5Y	*PT*	20.423	20.165	7.317*	6.983*	6.722*	6.204*	10.794*	9.737*
	SP	8.786*	8.752*	13.818**	13.412**	9.093*	8.525*	8.121*	7.337*
	IT	9.046*	9.008*	7.258*	6.81*	4.47*	4.418*	12.614*	10.148*
7Y	*PT*	11.575*	11.571*	12.747*	11.628*	6.762*	5.267*	13.547**	12.835**
	SP	11.298*	9.903*	11.488*	10.419*	7.677*	6.905*	7.84*	7.176*
	IT	10.984*	10.624*	5.378*	4.566*	4.875*	4.701*	12.701*	10.325*
10Y	*PT*	7.892*	7.022*	11.554*	9.068*	8.522*	6.764*	13.22*	12.768**
	SP	15.289**	13.109**	16.515***	14.561***	6.202*	5.799*	7.543*	7.21*
	IT	9.108*	8.938*	9.92*	7.085*	4.713*	4.688*	11.971*	10.117*
15Y	*PT*	-	-	-	-	9.774*	9.015*	13.757**	13.495**
	SP	11.958*	11.958*	6.384*	5*	12.518*	11.957*	9.211*	9.031*
	IT	-	-	3.913*	3.276*	9.192*	9.014*	13.371*	12.311**
30Y	*PT*	-	-	5.368*	4.533*	11.184*	10.693*	8.039*	7.757*
	SP	10.766*	9.839*	7.292*	4.627*	13.359*	13.246**	4.521*	4.197*
	IT	16.737***	16.726***	6.555*	4.076*	8.055*	7.116*	9.762*	7.635*

Note: *, **, *** indicate significance at 1%, 5% and 10% levels respectively.

Table A. 8 - Granger Causality Test between swap rates and bond yields

	Dependent/ Independent Variable	BEAR 1		BULL 1		BEAR 2		Post-Crisis	
		Lags = 4	Lags = 8	Lags = 4	Lags = 8	Lags = 4	Lags = 8	Lags = 4	Lags = 8
2Y	*PT,SWAP*								
	SWAP,PT								
	SP,SWAP								
	SWAP,SP								
	IT, SWAP								
	SWAP, IT								
	GE, SWAP								
	SWAP, GE								
5Y	*PT,SWAP*								
	SWAP,PT								
	SP,SWAP								
	SWAP,SP								
	IT, SWAP								
	SWAP, IT								
	GE, SWAP								
	SWAP, GE								
7Y	*PT,SWAP*								
	SWAP,PT								
	SP,SWAP								
	SWAP,SP								
	IT, SWAP								
	SWAP, IT								
	GE, SWAP								
	SWAP, GE								
10Y	*PT,SWAP*								
	SWAP,PT								
	SP,SWAP								
	SWAP,SP								
	IT, SWAP								
	SWAP, IT								
	GE, SWAP								
	SWAP, GE								
15Y	*PT,SWAP*	-	-	-	-		-		
	SWAP,PT	-	-	-	-		-		
	SP,SWAP								
	SWAP,SP								
	IT, SWAP	-	-						

	Dependent/ Independent Variable	BEAR 1		BULL 1		BEAR 2		Post-Crisis	
		Lags = 4	Lags = 8	Lags = 4	Lags = 8	Lags = 4	Lags = 8	Lags = 4	Lags = 8
	SWAP, IT	-	-						
	GE, SWAP								
	SWAP, GE								
30Y	*PT,SWAP*	-	-						
	SWAP,PT	-	-						
	SP,SWAP								
	SWAP,SP								
	IT, SWAP								
	SWAP, IT								
	GE, SWAP								
	SWAP, GE								

Table A. 9 - Granger Causality Test between German yields a, and Portugal, Spain and Italy yield

	Dependent/ Independent Variable	BEAR 1		BULL 1		BEAR 2		Post-Crisis	
		Lags = 4	Lags = 8	Lags = 4	Lags = 8	Lags = 4	Lags = 8	Lags = 4	Lags = 8
2Y	*PT,GE*								
	GE,PT								
	SP,GE								
	GE,SP								
	IT,GE								
	GE,IT								
5Y	*PT,GE*								
	GE,PT								
	SP,GE								
	GE,SP								
	IT,GE								
	GE,IT								
7Y	*PT,GE*								
	GE,PT								
	SP,GE								
	GE,SP								
	IT,GE								
	GE,IT								
10Y	*PT,GE*								
	GE,PT								
	SP,GE								
	GE,SP								
	IT,GE								
	GE,IT								
15Y	*PT,GE*	-	-	-	-		-		
	GE,PT	-	-	-	-		-		
	SP,GE								
	GE,SP								
	IT,GE	-	-						
	GE,IT	-	-						
30Y	*PT,GE*	-	-						
	GE,PT	-	-						
	SP,GE								
	GE,SP								
	IT,GE								
	GE,IT								

Table A. 10 - Results for pre-hedging using swaps for Italy

Period	Residual Maturity	N of Swaps	Successful	Successful (%)	+Δ Rates	Δ IT Rate < Δ Swap Rate	Δ IT Rate < Δ Swap Rate (%)
Bear 1	4Y	2	1	50%	1	1	100%
	5Y	36	31	86%	16	8	50%
	6Y	3	2	67%	0	0	
	9Y	3	3	100%	1	0	0%
	10Y	23	19	83%	10	7	70%
	11Y	7	5	71%	2	1	50%
	15Y	5	5	100%	3	3	100%
	29Y	2	2	100%	2	1	50%
	30Y	25	20	80%	13	5	38%
		106	88	83%	48	26	54%
Bull 1	4Y	8	7	88%	3	3	100%
	5Y	34	31	91%	20	13	65%
	9Y	1	1	100%	1	0	0%
	10Y	40	38	95%	21	13	62%
	11Y	5	5	100%	2	1	50%
	14Y	4	3	75%	3	2	67%
	15Y	9	8	89%	4	3	75%
	16Y	4	3	75%	3	1	33%
	30Y	11	11	100%	6	4	67%
		116	107	92%	63	40	63%
Bear 2	4Y	7	6	86%	4	2	50%
	5Y	14	13	93%	7	0	0%
	6Y	2	2	100%	2	1	50%
	10Y	11	8	73%	5	3	60%
	11Y	7	4	57%	2	1	50%
	12Y	1	0	0%	0	0	
	14Y	1	0	0%	0	0	
	15Y	3	3	100%	2	1	50%
	20Y	2	1	50%	1	0	0%
	29Y	1	0	0%	0	0	
	30Y	6	4	67%	4	1	25%
		55	41	75%	27	9	33%
Post-crisis	4Y	3	3	100%	2	0	0%
	5Y	19	13	68%	7	1	14%
	6Y	10	6	60%	3	1	33%
	7Y	18	11	61%	7	3	43%
	8Y	1	1	100%	1	0	0%
	9Y	1	1	100%	0	0	
	10Y	23	16	70%	9	3	33%
	11Y	1	0	0%	0	0	
	15Y	4	3	75%	2	0	0%
	16Y	3	2	67%	1	0	0%
	19Y	1	1	100%	1	0	0%
	28Y	2	2	100%	2	0	0%
	29Y	2	2	100%	1	0	0%
	30Y	9	7	78%	6	2	33%

		97	68	70%	42	10	24%

Table A. 11 - Results for pre-hedging using swaps for Portugal

Period	Residual Maturity	N of Swaps	Successful	Successful (%)	+Δ Rates	Δ PT Rate < Δ Swap Rate	Δ PT Rate < Δ Swap Rate (%)
Bear 1	5Y	4	4	100%	3	2	67%
	10Y	2	2	100%	0	0	
		6	6	100%	3	2	67%
Bull 1	3Y	6	6	100%	1	0	0%
	4Y	2	1	50%	1	0	0%
	5Y	3	2	67%	1	0	0%
	6Y	1	1	100%	1	0	0%
	10Y	7	7	100%	5	3	60%
	30Y	1	1	100%	0	0	
		20	18	90%	9	3	33%
Bear 2	3Y	1	1	100%	0	0	
	5Y	1	1	100%	0	0	
	6Y	3	3	100%	2	0	0%
	10Y	7	7	100%	3	2	67%
	15Y	3	2	67%	0	0	
	30Y	1	1	100%	1	0	0%
		16	15	94%	6	2	33%
Post-crisis	4Y	1	1	100%	1	0	0%
	5Y	3	1	33%	1	0	0%
	7Y	1	1	100%	0	0	
	10Y	18	14	78%	6	3	50%
	15Y	6	5	83%	1	1	100%
	16Y	1	0	0%	0	0	
	18Y	1	1	100%	0	0	
	26Y	1	0	0%	0	0	
	27Y	1	1	100%	0	0	
		33	24	73%	9	4	44%

Table A. 12 - Results for pre-hedging using futures for Italy

Period	Residual Maturity	N of Futures	Successful	Successful (%)	+Δ Rates	Δ IT Rate < Δ GE Rate	Δ IT Rate < Δ GE Rate (%)
Bear 2	4Y	5	3	60%	2	2	100%
	5Y	9	6	67%	5	2	40%
	6Y	2	1	50%	1	1	100%
	10Y	8	7	88%	3	1	33%
	11Y	3	0	0%	0	0	
	12Y	1	0	0%	0	0	
	14Y	1	0	0%	0	0	
	15Y	3	3	100%	2	1	50%
	20Y	2	0	0%	0	0	
	29Y	1	0	0%	0	0	
	30Y	4	2	50%	2	0	0%
		39	22	56%	15	7	47%
Post-crisis	4Y	3	2	67%	1	0	0%
	5Y	19	13	68%	4	0	0%
	6Y	10	6	60%	3	1	33%
	7Y	18	9	50%	4	3	75%
	8Y	1	1	100%	1	0	0%
	9Y	1	1	100%	0	0	
	10Y	23	17	74%	8	3	38%
	11Y	1	1	100%	1	0	0%
	15Y	4	3	75%	2	1	50%
	16Y	3	3	100%	1	1	100%
	19Y	1	0	0%	0	0	
	28Y	2	2	100%	2	1	50%
	29Y	2	2	100%	1	1	100%
	30Y	9	5	56%	4	1	25%
		97	65	67%	32	12	38%

Table A. 13 - Results for pre-hedging using futures for Portugal

Period	Residual Maturity	N of Futures	Successful	Successful (%)	+Δ Rates	Δ PT Rate < Δ GE Rate	Δ PT Rate < Δ GE Rate (%)
Bear 2	5Y	1	1	100%	0	0	
	6Y	2	2	100%	1	0	0%
	10Y	4	4	100%	2	2	100%
	15Y	3	3	100%	0	0	
	29Y	1	1	100%	0	0	
		11	11	100%	3	2	67%
Post-crisis	4Y	1	1	100%	1	0	0%
	5Y	3	1	33%	1	1	100%
	7Y	1	1	100%	0	0	
	10Y	18	15	83%	7	3	43%
	15Y	6	6	100%	1	0	0%
	16Y	1	1	100%	1	1	100%
	18Y	1	1	100%	0	0	
	26Y	1	1	100%	1	0	0%
	27Y	1	1	100%	0	0	
		33	28	85%	12	5	42%