Underpricing in sovereign price auctions in the Eurozone

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Abstract

This paper attempts to justify underpricing differences amongst primary and secondary market yields in Eurozone sovereign debt bonds. Through OLS estimations, the explanatory variables provided further clarity for discriminatory price auctions, but the interpretations provided are of similar content for all forms of auctions. Secondary market investors tend to react in a more uninformed and rash way than primary dealers as proved by further literature. There are instances of overpricing in the market, but the moments are scattered so that the price behavior or other discrete primary auction variables carry larger responsibility than the implemented macroeconomic control variables.

JEL Classification: E44; G12; H63

Keywords: Auctions, Primary, Secondary, Bond market, Underpricing, Europe, Asset Pricing

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1. Introduction

When governments incur public budget deficits, there regularly exists the need to deliver debt emissions to compensate for the overspending. In other instances, countries turn to sovereign debt emissions in order to cover already existent liabilities. Moreover, countries regularly conduct auctions to sell their debt. After selling their debt to primary market dealers, which are mainly institutions such as banks, brokerage houses or insurance agencies, the latter are responsible for selling sovereign debt to investors in the secondary market. This paper's goal is to compare the spread in prices from the primary market with the secondary one. The analysis with a Eurozone sample is interesting as most comparisons with sovereign debt auctions are done with a particular country which presents more profound historical data than most Eurozone countries do. Nevertheless, M. Jiménez et A. Mochón (2022)[2] present a complete study with a sample of OCDE countries, from which some Eurozone members for 10-year bonds. However, instead of studying the causes of underpricing changes over time, this paper focuses on achieving which auction type is better[3], if the uniform or the discriminatory auction. The conclusion achieved is "uniform systems obtain more favorable price spreads. However, the price spread standard deviation is lower and, therefore, more beneficial in discriminatory auctions." Which as gathered in the literature review, is a common conclusion, as other papers such as the latter attain parallel results. Using short-term auction data from Eurozone countries, such as Germany, France, Spain, Portugal, Greece and Ireland, there is a comparison with stronger, more reliable economies to be made against weaker and more likely

[2] All citations in this paper are linked to their specific Reference by holding *Ctrl* and clicking in the linked name or date.

[3] There are two auctions adhered to by most countries. The uniform-auction price particularity is that all primary dealers who have sovereign bonds allocated to them, pay equal price despite the bid made. Whereas in the discriminatory auction all bids allocated are paid by the bid amount, i.e., it is a pay as you bid system where each primary dealer can pay a discrete amount that differs from others depending on each other's bids. Nevertheless, all auctions of both types are conducted in a similar manner, the indexed price for each bond can be the same for all accepted buyers (uniform) or can be different depending on the bids allocated (discriminatory).

to default on their sovereign debt economies. Other Eurozone sovereign debt auctions and similar literature are used to test for robustness of the remaining regression analysis as done by A. Noel et M. Wu. (2024), as explained further. Moreover, other statistical tests are conducted to assess the unbiasedness of the estimators.

This paper focuses on a sample which for some period of time lacks individual monetary policy. The former senior vice president of the World Bank and Nobel winning economist Joseph Stiglitz (2017) has shown to be a strong advocate for the argument European countries struggle in severe financial conditions as during the 2010's sovereign debt crisis, where some countries which are sampled in this paper showed prolonged difficulties by not being able to perform expansionary measures in the right moment and in a particular amount as the ECB might have the time made. As presented in Appendix A, numerous austerity measures were implemented, and most affected countries were aided by hundreds of billions of euros by the IMF and the European Central Bank (ECB). Also, in Appendix A, it is showed how sovereign bond prices suffered a toll during this period as well as they did for the pandemic.

Through empirical research, the paper is intended to understand the causality of macroeconomic factors (which are constructed as control variables of the regressions) and primary market variables proxies of demand and supply from the institutional dealers have on the spread between the secondary and primary market. As these dealers intend to purchase sovereign bonds, both for security and profit in reselling, most of the time the intention is to append a premium associated with newly issued secondary market bonds. For that reason, underpricing is common when computing the gap between the secondary market price to the primary one. It is relevant to analyze short-term sovereign bonds which sometimes provide overpricing instances as large as the largest underpricing gap (as presented further and in discrete analysis in Appendix A, France for instance, has an underprice of roughly 0.25 and overprice of -0.2). Most gathered time series are performed between 2011 and 2024, which

provides a prolonged timeframe for both expansionist and contractionary periods, avoiding "skewness" for shorter periods.

2. Literature Review

This study core structure has parallelisms with the papers from Sara G. Castellanos (2001) and A. Noel et M. Wu (2024). In terms of methodology presence focused on underpricing between the primary and secondary market of named economies, both papers focus on finding evidence and scale of spread differences in the prices of the two markets.

There is a thorough research range on equity underpricing, particularly in IPO phases, mainly in the US stock market. Consequently, the fixed income market research on this matter presents richness for the corporate bond market. T. Rischen and E. Theissen (2021) presented for the first time a study on the Euro Area corporate bond market, pursuing the hypothesis that underpricing is larger during downturn economic periods. An older research also focused on the same hypothesis, but for underpricing of the early 80's on newly issued corporate bonds of the Swiss corporate bond market (Wasserfallen et Wydler. 1988). Most of this underpricing is empirically associated with transaction costs, which can also be challenged for any price differential between sovereign primary and secondary markets. There was further research on this matter but, most recently, a parallel WP was also developed for the US corporate bond market (Kozhanov et Ogden. 2012). Interestingly, this research paper benchmarked indexes with the corporate yields and contrasted the underpricing and liquidity effects on plain vanilla corporate bonds. The relationship with liquidity has a similar important effect in underpricing and is accounted for as a factor in this sovereign bond paper. Finally, and although there are similar works for the US, the level of underpricing in Chinese corporate bonds is also somewhat

justified (Si Xu et al. 2017). A large portion of underpricing is justified by the reputation of the underwriter when in transactions between issuers and market dealers.

When looking into prior research on sovereign debt markets, most research focuses on contrasting underpricing magnitudes in different types of auctions. A relevant paper on the matter focused on Iceland's change of auctions in 2009 (Noel et Wu. 2024) and how switching from a uniform-price auction to a discriminatory form changes the magnitude of the underpricing. This can relate with the primary dealer commission costs change, which is argued to be a statistical reason for the decrease in underpricing, once the change to discriminatory form was implemented. A challenge encountered by the authors was the merge of primary and secondary market yields from different sources, that can sometimes offer misaligned timeframes. Differing from this relation is Kremer et Nyborg (2003), which with the usage of datasets from US and UK treasury bonds, reported that with a trending discrete analysis on price and quantity levels, uniform-price auctions have a more pronounced level of underpricing dealt with, meaning the provided extensive theoretical literature relating uniform-price auctions to have more underpricing than discriminatory are not accounting for this analysis. Similarly, Nyborg (Nyborg et al. 2005) presented similar research of uniform-price auctions for Finland. As before, the price behavior of investors is accounted for as Finnish Auctions are established by historical level of demands from prior results. A different analysis done between primary and secondary sovereign markets is Eisl (Eisl et al. 2018). The latter focus on explaining how price behavior in the Eurozone can affect the demand magnitude and the price level of a primary auction. As one gets closer to the auction date, trading volume increases significantly in the secondary market a few days before. Primary dealers also adjust their bids in accordance with the risk profile change from a country's sovereign debt. An alternate analysis is done in Corradin et R.-Moreno (2014), where the yield-to-maturity of US bonds overvalue that of Euro Area issuers even when accounting for exchange rate risk. The argument is made that the

European Central Bank (ECB) operates liquidity policies that prevent bonds in the Euro Area from increasing implied costs or achieve higher levels of volatility. An extremely relevant paper for the current research landscape is Beetsma (Beetsma et al. 2013). The ECB paper focuses on understanding secondary market yields connected with auction dates for the Italian treasury and German Finance Agency. The achieved results can connect with this study as the Italian anticipation differential is more pronounced than the almost nonexistent in Germany for longer maturity bonds. Moreover, a macroprudential paper of the Euro Sovereign Debt Crisis is presented through the ECB by De Santis (2012). A distinction is made between the level of price behavior relative to investors demand in stronger European Economies and the yield swift change a-posteriori of the Greece rating downgrade. Another paper relating to rating influence in bond markets is Mietzner et al. (2018). A significant relation is established between default swaps rates and the default implied probability with overly favorable ratings. This spread proves to be a positive proxy in interactions against rating agencies assigned ratings as higher-quality firms are able to avoid these inflationary ratings and can differentiate in such a spread with a strong statistical significance.

3. Data and Methodology

For this study, timeseries data is used from different Eurozone Countries throughout the available time-series dimension for each economy. Relative to the sample chosen, one recognizes the trend used with Western European countries. The main reason for this choice is due to structure differences in auctions and more importantly, the modest range of auctions data most East European countries present, justified by a reduced number of years since the Euro has been integrated into their economic system. One can argue that, by using historical exchange rates between the country's previous currency to know the Euro, then this empirical research could gather even more cross-country analysis. This is not optimal as the auctions are

priced accounting for the currency adhered to at the time. For this reason, prices, if a country already was instituted as a Euro Area state-member, have differences in demand, particularly for not sharing common currency with Europe's largest economic monetary union (which can be argued as a stability peg for new members). Moreover, there are pronounced differences each sampled country has of showing their variables. In that way, this paper tries to integrate most of these countries' differences in order to accurately regress each in a clean and comparable form.

Another meaningful remark is the use of short-term bonds instead of the more popular long-term ones. There are two main reasons derived from the differences in maturity. Firstly, that Eurozone countries are integrated in the same issuance regulations, the number of auctions is reduced in comparison to other economies, making the long-term sample, which regularly presents smaller issues than the short-term bonds, of a sample less desirable for the statistically significant standards. Moreover, short-term bonds are more liquid, easing possible comparisons in historical demand levels and more easily construct the yield spread, which will be the dependent variable of our regression, between the primary market rate and the secondary one. Secondly, the shorter the maturity, the less likely price reactions occur to disruptive economic events (such as high inflation, economic recession or sovereign debt default risks). Hence, by using maturities equal to or shorter than 12 months, the model can receive less noisy data. This choice of bonds was also used in a relevant and already-named paper on the matter in Sara G. Castellanos (2001).

The price formula, as described in table 2 notes in Appendix A, follows the same formula for secondary market prices. The intention when computing this price is that, as theoretically an announced maturity by the issuers will have the same number of days as that of the secondary market, it is the implied yield between both markets that is intended to affect the price when computing the price differential at a fixed given moment. For that reason, when scattering

further the time-series, it becomes interesting to account for both the dispersion in days for different periods as the underpricing or overpricing differences (whichever applies). Thus, consider the formula as follows:

$$DV = \frac{NV}{(1+\frac{i}{100}\times\frac{n}{360})},^{4}$$

After conducting an analysis of cross-maturities price differential as in Appendix A, it is relevant to compare the price behavior across different countries. Even though, and as was already stated, the period of stagnant economic growth affected all Euro Area economies that presented similar periods and magnitude in negative interest rates after the early 2010's sovereign debt crisis until nearly the start of the pandemic constraints. Furthermore, since there are short periods of high-interest rate shifts, we can clearly see a correlation between all these countries. Whereas Portugal presents more volatility in the spread difference, particularly in the 12-month maturity, all countries converge when meaningful yield transformations occur. This is due to the fact all Euro Area countries share the same monetary policy authority, creating a strong correlation when interest rates are conducted, as is clearly seen in the most recent price expansion trend that signifies a common interest rate policy.

3.1.Modeling Rules

This paper conducts an OLS regression in cross-country analysis, taking the main focus of study into consideration. Aside from that, it is keen on evaluating differences in the magnitude of underpricing from different auctions and different policy reactions when one faces a period of economic turmoil.

[4] DV- discount value; NV- nominal value; i- last accepted price by the issuer; n- number of days between the issuance, i.e., settlement date, and maturity.

An evidentiary remark in relative differences, when researching variables between the primary and secondary market, is a discrete analysis in price behavior. Unfortunately, no country sampled provides historical value for primary market dealers' bids. This is not optimal when researching underpricing since, as suggested by Sara G. Castellanos (2001), one profoundly meaningful factor affecting differences from one auction to the prior is the level of interest bid by selected investors. More recent academic researchers, such as A. Noel et M. Wu., 2024, conduct regressions that use discrete variables of primary market dealers such as, number of bids per bidder or average amount of bids, which are variables not easily accessible to outside researchers. Even though this regression recognizes the usage of proxies for competitive phase investors' expectations, it lacks historical values that can affect the dispersion and level of representation. For that reason, all necessary statistical tests are conducted to guarantee a significance of the regression.

As already discussed, our dependent variable is the difference between the yields in both markets. The variable could be the rate of return difference between the price of the secondary against the price of the primary market, but both named papers concluded that the sole difference in prices brought more statistical significance to their models (prices are obtained by the yields computed through the price formula already given for the discounted value), as follows:

$$UNDERP = P_{Secondary} - P_{Primary}$$

As both the ECB database and Primary Marker Issuers secondary market's trading platforms present the short-term bonds in the form of yields, it is this paper's suggestion to gather the presented yields and compute the price using a fixed number of days until maturity. This decision is based on using the most exact number of days between the settlement date and the scheduled maturity date present in each auction and computing each price for the yield priced

in the secondary market (gathered from brokerage platforms that resell fixed income securities directly in the secondary market). Finally, as some results weren't able to pass heteroskedasticity tests, and in accordance with Barndorff-Nielsen (1991), to handle error terms to asymptotic normal distributions and reduce risk of biasedness by irregular variance, regression with higher risk have a transformation of the dependent variable. Although it would be optimal to implement a log likelihood ratio in the dependent variable, the presence of overpricing in almost all datasets (i.e., negative values in the price differential), requires the usage of signed log likelihood ratio:

$$slog(UNDERP) = sign(UNDERP) \times log(|UNDERP| + 1),$$

sign ensures the transformed values retain the sign of the original data, *log(|x|+1)* to ensure that negative values, when transformation is made, don't become undefined transformations.

The first focus is intended to represent demand through the available parameters. In order to accurately analyze the level of representation of more risk averse and smaller bidders in auctions over time, we will use the ratio between the number of non-competitive bids (SMALPAR) over the total amount of bids in any given auction. The paper from Shoshana Vasserman (2021) reflects that more risk averse bidders tend to be of smaller size and bid less during high volatility periods. This research helps to confirm that the variable SMALPAR can serve as a good proxy for the level of participation of smaller investors in the primary market, which can pose some level of correlation with higher market uncertainty periods.

Furthermore, to use as a variable for the range of competition in the competitive phase of the auctions, the bid-to-cover ratio (COVER) will be used as a proxy. This ratio is a relevant proxy for competition as sometimes, increased presence in auctions or more accepted bids by themselves may not mean there is more competition, since the issuance volume may be larger than usual. Thus, this variable guarantees that there is a proper proxy for competition. This ratio

is extensively used in literature and aside from already named papers, the 10-year underpricing analysis was conducted with the bid-to-cover as a pivotal ratio (M. Jiménez et A. Mochón. 2022). Another relevant variable is the inverse formula of the bid-to-cover ratio but for all auction phases. The pro-rata ratio represents the relative level of acceptance by issuers relative to the total bid amount (allotment above total bid value). This variable (PRORAT) is intended to work as a competition proxy for all auction phases. In this variable, some of the sampled countries presented a poor range of variables, so the described computation is made and used as a pro-rata for that country (Sara G. Castellano. 2001).

The second type of variables used in this regression is intended to represent the level of supply by the issuers. The issue size announced (ISSUESIZE) prior to the auction is a relevant proxy for investors' expectations and affects the price differentials as investors account for a particular value accessible. When any announced issue size is a sort of range, an average of any particular range is used as the expected issue size (i.e., if the issue size amount is €1.000 million and €1.500 million, then the used issue size for the dataset is €1.250 million). Thus, this regression accounts for issuers' expectations of the market demand and also serves to evaluate the ability for stronger investors to control the market price, i.e., the larger the issue size announced, the harder it gets to see cartel control of auction results. Another variable suggested by Sara G. Castellanos (2001) is the amount of other maturity auctions held on the same day. This variable was used in all regressions and didn't show any statistical significance in any. For this reason, and although this variable showed potential at the time, it was later dropped from the final regression. Aside from primary market level variables, this regression also has secondary market variables. These variables are intended to reflect liquidity levels in each bond maturity. The first variable is the outstanding number of bonds in the secondary market (OUTSEC). However, public access to historical values, such as this one, is scarce and for that reason, this regression will use a similar variable (with the same name OUTSEC) that is

intended to relate similarly with the original proxy. Thus, the volume in the secondary market yields for each maturity will be used. This variable also captures the level of liquidity the bond market has in any given time. Stronger liquidity is slightly related to a narrowing of the underpricing felt between both markets as it shown in (Jame Brugler et al. 2022).

Our last independent variables are a proxy of market uncertainty periods. Since the sample presented is in Europe, there is room to use the implied volatility (IMPVOL) VSTOXX from the Euro STOXX 50 Index level as a sentiment of the market with its expected fear of market expectations. For that reason, we use the historical values of the VSTOXX index as a proxy for market sentiment. Moreover, there is an additional dummy variable δHIGHVOL to estimate high stress economic periods, which is signaled when the VSTOXX market average is surpassed by one standard deviation. Although bold, the connection established between the equity and sovereign bond market made by A. Ilmanen (2003). One remark must be made in the sense that countries such as Portugal have no direct representation in the Euro STOXX 50 Index, meaning this parameter may not work efficiently as a proxy for countries with no represented companies. Thus, for countries that have no representation of at least one company in the Euro STOXX 50 Index, the volatility from the largest market capitalization of their own country will be implemented (in the case of Portugal, empirical results suggest that merely common currency doesn't suffice to use the main European Index, as results are not statistically significant for any maturity where it was conducted).

Finally, this regression must also develop control variables for time trends. Aside from market uncertainty, there are macroeconomic factors that may mold underpricing trends and go unnoticed in this regression. Therefore, historic data source from Debt-to-GDP from each country (DGDP) is used as a proxy for the level of indebtedness each country presents. This is optimal in the sense that given the size of some maturities, accounting for factors such as public debt, which directly affects the probability of default of a country, creates a perfect proxy for

investors' expectations with macro factors in mind. Moreover, the deficit/surplus to GDP (DEF) is also presented for shorter term reasons, as some large changes in the magnitude of debt do not affect the immediate difference in prices between both markets. Other benchmarks used for this research paper are proxies of interest rate changes of the ECB. Firstly, a discriminated country yield curve spread is computed by associating the 10-year bond yield to the 2-year bond for the same trading day (YLDCUR). When this spread achieves negative values, it means the 2- year implied yield surpasses that of the 10-year bond for the same trading day, suggesting an increased risk of economic recession for that particular country. Interestingly, the correlation of all spreads was conducted and the yield performance along different countries' timeframe is highly positively correlated, in a meaningful way. For instance, the yield curve spread correlation between Spain and Germany, countries that presented different types of auctions and a different level of primary market investors, is of 0,858, which is the third largest correlation between all countries. Secondly, another variable used profoundly in the EU macroprudential policy is the spread between the weekly EURIBOR rate and the overnight deposit from the ECB, both annualized (EURIBOR). The reasoning behind a negative spread, if it is caused by a decrease in the EURIBOR, is due to quantitative easing policies by the Central Bank, reflecting the monetary policy in larger approximations. If caused by the increase in the overnight rate, one can understand the increase in liquidity constraints pushed by commercial banks' need for shortening deposits. Y. Pérez et al. (2023), which with support by the Bank of Spain, provides in their study the relevance a spread between intrabank rate such is €STR (and in this regression, EURIBOR) and the overnight deposit by the already enumerated reasons. All macro data used for the regression is gathered from the ECB Data Portal. All secondary market data is gathered, either by macroeconomic data frames from ECB Data Portal, or from brokerage houses which in turn gather their values from Bloomberg. With all variables presented, the regression for the price differential can be computed as follows:

$$UNDERP = \beta_1 SMALPAR + \beta_2 COVER + \beta_3 PRORAT + \beta_4 \log(ISSUESIZE) + \beta_5 OUTSEC + \beta_6 IMPVOL + \delta HIGHVOL + \beta_7 DEBT + \beta_8 DEFICIT + \beta_9 EURIBOR + \beta_{10} YLDCUR ,$$

This regression is assumed to have linear relationships amongst all presented variables and is tested for multicollinearity, autocorrelation and heteroskedasticity.

4. Results

When conducting the regressions' results, and apart from France where a comparison was derived from, not all variables present for each country are used in the regression. Instead, each country has similar independent and control variables throughout different maturities. This occurs since some countries lack meaningful independent variables that affect the primary market price, and this research paper recurred to a lot of different control variables to challenge the difference in prices throughout timeframes and guarantee further improvement in the statistical representation of the regressors. Thus, it is a requirement of avoiding overfitting variables for some regressions, which tends to occur if all or more variables are implemented.

As already stated, when using the signed logarithmic likelihood ratio, there is the risk of decreasing the linearity relation between the dependent and independent variables and the original interpretation of the most significant variables. Hence, only when regressions fail both heteroskedasticity tests, or present low p-values for the null hypothesis of homoskedasticity presence, is when the *Slog* transformation is implemented to the dependent variable. In the statistical tests section, it will be carefully explained how this affected the regressions and, more importantly, the heteroskedasticity issues.

Furthermore, there was the requirement to create interactions within some auction related variables to create statistical significance in at least a 90% confidence interval. With this particularly, some countries do have interactions for some maturities or just the raw variables

as is. Nevertheless, when using these interactions, there was always the imposed requirement of remaining the same independent variables across maturities to ease interpretations of the results.

Table 3: Fixed effects and overfitted regressions: France

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
SMALPAR	0.142***	0.068***	0.119***	0.120***	0.252***	0.255***
	(0.018)	(0.008)	(0.012)	(0.013)	(0.022)	(0.025)
COVER	...	-0.004***	-0.001*	-0.003*	...	-0.002
	(...)	(0.001)	(0.001)	(0.001)	(...)	(0.004)
PRORAT	...	-0.016*	...	-0.020	-0.035**	-0.054
	(...)	(0.009)	(...)	(0.017)	(0.016)	(0.035)
COVER × PRORAT	-0.075***	...	...	...	...	...
	(0.015)	(...)	(...)	(...)	(...)	(...)
log_ISSUESIZE	0.006***	0.000	-0.003***	-0.001	-0.001	0.004
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)
OUTSEC	-0.009	-0.012	0.071***	0.070***	...	0.004
	(0.010)	(0.009)	(0.017)	(0.017)	(...)	(0.027)
IMPVOL	...	...	-0.032**	-0.027*	...	-0.034
	(...)	(...)	(0.014)	(0.014)	(...)	(0.028)
HIGHVOL	0.002	0.002	-0.006**	-0.006**	0.008*	0.0013**
	(0.001)	(0.001)	(0.003)	(0.003)	(0.004)	(0.006)
DEBT	0.025***	0.011**	0.016**	0.018**	-0.019	-0.016
	(0.005)	(0.004)	(0.007)	(0.007)	(0.013)	(0.015)
DEFICIT	0.095***	0.064**	...	0.073	...	0.036
	(0.024)	(0.027)	(...)	(0.048)	(...)	(0.097)
EURIBOR	...	-0.023	-0.357***	-0.369***	-0.0462***	-0.541***
	(...)	(0.042)	(0.070)	(0.075)	(0.131)	(0.155)
YLDCUR	...	-0.044	...	-0.102	...	-0.090
	(...)	(0.046)	(...)	(0.081)	(...)	(0.160)
Observations	746	746	758	758	702	702
Adjusted R-squared	0.1546	0.1331	0.2178	0.2178	0.2324	0.2415

Notes: Standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. (1) and (2) are three-month, (3) and (4) are six-month and (5) and (6) are 12-month.

Table 4: Fixed effects and overfitted regressions:Spain and Portugal

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
SMALPAR	1.601	-2.384*	-1.328	...	0.782***	-0.058
	(1.289)	(1.431)	(1.022)	(...)	(0.190)	(0.116)
COVER	-0.0134**	-0.014	0.058	-0.004	-0.031**	0.005
	(0.007)	(0.015)	(0.097)	(0.002)	(0.015)	(0.013)
PRORAT	...	...	...	...	...	...
	(...)	(...)	(...)	(...)	(...)	(...)
log_ISSUESIZE	-0.025***	-0.037**	-0.301***	0.006	0.040	-0.003
	(0.009)	(0.018)	(0.092)	(0.008)	(0.030)	(0.005)
OUTSEC	-0.696***	0.495	0.823	-0.100***	-0.471***	-0.188**
	(0.171)	(0.322)	(0.736)	(0.037)	(0.056)	(0.077)
IMPVOL	0.511**	0.948**	0.508	...	...	...
	(0.198)	(0.439)	(0.658)	(...)	(...)	(...)
HIGHVOL	...	...	...	...	...	...
	(...)	(...)	(...)	(...)	(...)	(...)
DEBT	...	...	2.289***	-3.827	-25.700	...
	(...)	(...)	(0.753)	(4.397)	(17.238)	(...)
DEFICIT	...	...	5.972***	...	...	-45.066
	(...)	(...)	(1.727)	(...)	(...)	(30.181)
EURIBOR	-4.419***	-14.231***	-19.463***	-0.379	...	...
	(1.341)	(2.965)	(4.303)	(0.534)	(...)	(...)
YLDCUR	7.742***	6.765*	13.073*	0.573	4.828***	-0.181
	(1.903)	(4.103)	(7.740)	(0.389)	(0.957)	(0.968)
Observations	149	151	143	54	71	106
Adjusted R-squared	0.4434	0.3545	0.3663	0.3394	0.8083	0.1008

Notes: Standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. (1), (2) and (3) are regressions for 3, 6 and 12-month Spanish sovereign bonds. (4), (5) and (6) are the regressions for the 3, 6 and 12 month Portuguese sovereign bonds. For comparison, in this results table, only regression (4) does not present a transformed "slog(UNDERP)" as an independent variable.

Table 5: Fixed effects and overfitted regressions:Greece, Ireland and Germany

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
SMALPAR	...	...	2.703	-9.477*	...	...
	(...)	(...)	(1.921)	(4.967)	(...)	(...)
COVER	...	-0.144	-0.136	-0.004	...	...
	(...)	(0.055)	(0.159)	(0.002)	(...)	(...)
SMALPAR × COVER	...	...	...	...	-0.006	-0.020
	(...)	(...)	(...)	(...)	(0.011)	(0.017)
PRORAT	...	...	1.832*	...	...	...
	(...)	(...)	(0.941)	(...)	(...)	(...)
COVER × PRORAT	-0.209	...	...	...	...	...
	(0.179)	(...)	(...)	(...)	(...)	(...)
log_ISSUESIZE	-0.032	-0.124***	-0.260**	...	0.006	0.015**
	(0.035)	(0.055)	(0.092)	(...)	(0.004)	(0.007)
OUTSEC	-0.086***	0.006	0.643	-0.180	0.310***	0.123*
	(0.009)	(0.043)	(1.406)	(0.232)	(0.058)	(0.063)
IMPVOL	-0.776***	...	...	...	...	...
	(0.214)	(...)	(...)	(...)	(...)	(...)
HIGHVOL	...	-0.409	...	...	0.009	-0.020**
	(...)	(0.082)	(...)	(...)	(0.009)	(...)
DEBT	0.325***	0.562***	...	0.286	-0.073	-0.168**
	(0.104)	(0.166)	(...)	(0.200)	(0.051)	(0.083)
DEFICIT	...	...	...	...	...	...
	(...)	(...)	(...)	(...)	(...)	(...)
EURIBOR	...	-5.978**	-129.105**	167.625***	-1.559***	-1.330***
	(...)	(2.933)	(52.166)	(31.776)	(0.213)	(0.282)
YLDCUR	...	-0.028	133.300***	...	0.187	1.310**
	(...)	(0.023)	(42.674)	(...)	(0.428)	(0.654)
Observations	155	159	29	14	192	184
Adjusted R-squared	0.6526	0.3593	0.7038	0.9937	0.3017	0.1837

Notes: Standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. (1) and (2) are regressions for 3 and 6-months of Greece sovereign bond market. (3) and (4) are regressions for 6 and 12-month Irish sovereign bonds. (5) and (6) are the regressions for the 6 and 12 month German sovereign bonds. For comparison, in this results table, only regression (1) and (2) does present a transformed "slog(UNDERP)" as an independent variable.

All regressions provide overall satisfactory results in terms of the sign and significance of coefficients and in terms of the explanatory power of the regressions.

4.1. Coefficient interpretations

Even though this paper focuses on comparing results in a cross-country analysis, one must value the sample size differences amongst distinct countries as well as across maturities. Thus, when establishing comparisons, the French results will work as the pivot of the rest of the regressions. Looking at SMALPAR significance levels and the value of the coefficients, the latter presents strong significance values for France and other scattered maturities from other countries. Aside from the 6-month Portuguese regression (0.782), all significant values point to a negatively slopped relation with underpricing. Although a primary market variable, SMALPAR alludes to secondary market expectations as noncompetitive bids don't affect the primary market marginal price directly but do control the auction price volatility, interlinking with secondary market purchasing power and the scale of demand. When SMALPAR increases it reflects small investors' intents, maintaining the primary price for the particular auction stable and narrowing the gap of secondary and primary auctions. This is an occurrence if accounting for the reaction of non-competitive bids to later auctions. These results are in line with M. Shao (2010), which studies the meaningfulness of non-competitive phases.

Another two independent variables that show interesting results are COVER and PRORAT. Even accounting for interactions with other variables, COVER has a predominantly negative relation with the underpricing differential. This is seen in French regressions and shorter-term Spanish and Portuguese regressions. As is provided by Sara G. Castellanos (2001), and although at a less significant level, high COVER signals to either underestimated demand by suppliers or to a large demand from investors relative to announced issue valued. Thus, when one of these two scenarios occurs, the primary market price increases, which in ceteris paribus, narrows the gap of underpricing. PRORAT is used in less regression and frequently interacts with other primary market variables. This occurs since normally this ratio has weak p-values

when regressions are scattered, even when controlling for variance by logging the variable. For that reason, it is difficult to take any interpretations without accounting for the meaning of the ratio itself. When PRORAT is high, the level of allotment relative to an average bid can be high. Hence, high PRORAT means low demand levels, which in turn means lower primary prices and thus a larger gap. Most academic papers have difficulties achieving any level of significance for this ratio and thus this variable is commonly disregarded. Nevertheless, a theoretical interpretation is provided.

As most variables are a form of relative ratios, the only frequently logged is ISSUE VALUE. This variable represents the announced issuance of bonds by the government prior to the auction. What can be attested to this regressor is the announced issuance does have some effect on both the primary and the secondary price, but as provided by Sara G. Castellanos (2001), it surprisingly provides nuanced effects of coefficients closer to 0. Hereafter, suppliers announced supply affects both market prices similarly and in a less magnified way. This can be reasoned as most of the announced issue values do not align with the final allocated amount. Most of the time, allocated values surpass the preestablish one by the issuer.

The volatility of the secondary market yields within the last 30 days (last 22 business days) has some fairly interesting results. The OUTSEC is a variable which has recurring statistical significance at the 1% level in a wide range of countries. Indeed, the coefficients range from slightly negative to positive values. The pattern identified is, higher volatility increases the spread in underpricing for “strong” economies, i.e., Germany and France. The reasoning behind this was inferred in Hnatkovska et Köhler (2018) where a relationship between large and small economies has a gap in market and macroeconomic parameters volatility. Sovereign bonds such as France and Germany are some of the most popular in Europe and even in large periods of uncertainty, their implied risk of default tends to be more stable

than the main affected economies by the European Sovereign Debt Crisis. Moreover, as described by G. Ordoñez et al (2022), secondary investors tend to have individual less purchasing power and less access to information. For that reason, when selecting the best sovereign bond investment options in the Eurozone, Germany and perhaps France tend to be more certainly placed in an investment portfolio. Thus, when more likely to default economies, such as Greece or Portugal present high levels of yield volatility, there is a trend to decrease underpricing as secondary market investors are more probable to worry about the winner's curse likelihood scenario.

IMPVOL is represented as lesser frequency than HIGHVOL for two main reasons. Firstly, it presents low statistical significance, which is relatively common as correlations between the equity market and the bond market vary extensively. A paper like that of A. Ilmanen (2003) as many more researchers, focuses on understanding the relation and behavioral patterns between both markets. It is identified in the study the uncertainty of named relationships in an over 5 decades timeframe. For this reason, the European "fear index" presents very little relevance in a fixed income market such as the short-term sovereign debt market. Contrary to IMPVOL, HIGHVOL appears as a significant variable for many regressions and with some causation linked to it. Mainly, as HIGHVOL identifies periods of one standard deviation over the IMPVOL mean, it creates a proxy for unusual market volatility which, contrary to the routine scattered equity volatility, spillovers in a more impactful way into the sovereign market. As it stands, countries such as Germany and France are the most affected by this variable as they have more companies as components of the EUROSTOXX 50. There was a test for the same variables but for some national equity market, but it did not provide many reasonable conclusions. To conclude, when the dummy variable HIGHVOL is a "1", i.e. it is present above the set standard, Germany and France underpricing narrows (-0.02

and -0.006, respectively) due to primary market dealers recurring more to sovereign bonds to hedge the equity instability.

Entering in more macroprudential control variables, DEBT presents large statistical significance in a wide range of samples as DEFICIT does. However, there is a trend amongst both variables. Whereas DEBT is more pronounced in longer maturities, DEFICIT is more recurringly significant with low p-values in shorter maturities. The coefficients are less pronounced in French regressions as DEFICIT and DEBT are scattered in a quarterly and monthly basis, respectively. As already said, France issues bonds on a weekly basis, so it creates the issue of some bonds presenting repetitive values for the DEFICIT for almost three months. Both coefficients present a linear relationship with underpricing. On one hand, as France is one of the power houses in the EU, secondary market investors purchase a stable amount of bonds despite the increasing value of Debt-to-GDP ratio. On the other hand, primary dealers are focused on these parameters, thus they charge larger secondary market prices if the risk of default increases, and purchase in the primary market at a discount. Therefore, when in periods of contractionary activity, strong economies widen the underpricing gap with higher Deficits and Public Debt.

As already mentioned, the EURIBOR spread is used to account for shifts in the ECB interest rate and liquidity issues when in an expansionary period. Interestingly, this spread is statistically significant across almost all sampled countries and throughout different maturities. Thus, when EURIBOR attains higher values, we are in presence of an economic cycle slowdown and the annualized overnight deposit of the ECB doesn't affect the overall spread. In contrast, when in an expansionary period, the Euribor decreases and to account for liquidity constraints amongst relevant institutions, the overnight annualized rate can achieve values that turn the spread negative. When this spread increases, the underpricing narrows due to primary

dealers having easier arbitrage and funding conditions relative to secondary market investors. Primary ones have more accessibility to create credit than secondary market ones, affecting the level of demand in both markets in a contrasting way.

Finally, the YLDCUR variable is more present in "weaker" economies, but at a significance level below that of the EURIBOR in economic cycle representation. French and Germany have less significance in these variables, as the used spread to predict regressions is made of longer-term maturities. Hence, these variables affect economies that had more pronounced recessions in the past such as Portugal, Spain, Greece and Ireland. The coefficient tends to be positive, which means a larger spread between the 10-year and 2-year sovereign bonds increases the underpricing differential. Higher spread means there is the likelihood of an expansionary economic scenario, which means secondary investors will increase demand at a higher rate than primary market dealers, who will not react with such instability. One recognizes that it is possible to add more macro variables to the regression to further explain the differentials. However, there is the strong risk of overfitting the model as more macroeconomic variables could create multicollinearity and correlations above acceptable rates.

One final remark has to do with the observation's disparities. Countries with small sample sizes, even for an extended timeframe, are more likely to have most of the dispersions explained by the presented independent variables. This event occurs since, even with a large scatter of price differentials, control variables can be associated with different price differentials without repeating some ratios for different auction events as it happened in the French regressions. With this in mind, we can see low observed regressions present larger adjusted R-squared due more to control variables of macroeconomic factors than discrete auction variables.

Considering the difference in auction type for each country sampled here, it is interesting to notice that macroeconomic factors apply similarly for both uniform-price auctions

as discriminatory ones. Nonetheless, discriminatory auctions regressions have more significant variables related to the primary auction. As in uniform-price auctions all accepted bids in the competitive phase are paid at equal rates, primary variables are less able to explain the difference in prices than they do in discriminatory auctions. Even though M. Brenner et al. (2009) understands the preference from investors to uniform auction price, discriminatory auctions marginal price appear to be explained better when differentiating with the secondary market prices than uniform ones.

4.2. Statistical tests background

When it comes to robustness check of these regressions, it is applied the method for underpricing calculation both in Sara G. Castellanos (2001) and A. Noel et M. Wu (2024) which suffered extensive robustness checks. For this reason, no more significant tests were conducted as both these papers provide evidence of underpricing computation methods could be conducted as seen earlier in this paper.

In terms of multicollinearity tests, all regressions passed with a VIF ratio[5] in all used variables strongly below the 10, averaging between 1.1 and 2.9 and with correlation matrixes strongly below the 80% metric both for positive as negative, which suggests low multicollinearity across the data sets. As already discussed, too many macroeconomic control variables pose a risk of overfitting regressions, so most maturities are only regressed with the most significant macroeconomic variables for a particular country in order to ease the interpretations already conducted. The Breusch Pagan and White tests[6] were conducted in all regressions to test for heteroskedasticity presence. Some regressions posed results where fitted values may present heteroskedasticity. In order to maintain the reputation and unbiasedness of

[5] As represented in the first table of Appendix B
[6] As represented in the first table of Appendix B

each estimator, the dependent variable suffered a slog transformation, which saw an increase of the p-value for the null hypothesis “Reject Homoskedasticity”. Nevertheless, some regressions didn’t pass this test in all confidence intervals, with a 1% p-value rejecting homoskedasticity for most of the original heteroskedasticity failed tests. Thus, in order to conduct correct interpretations, all regressions that passed at least one of the tests were interpreted in a coherent manner and with the heteroskedasticity risk in mind. Another remark that could be made is that the samples with more observations posed the most issues which can make sense as some control variables are repeated for some auctions as already stated.

One issue that should be discussed is: Why not log more variables if the heteroskedasticity can be a problem in some regressions? The main reason for not logging more variables in a more consistent frequency is due to the increased risk of incurring in multicollinearity and losing the linearity amongst them, which could impose wrong interpretation risks. Some regressions were tested for this, and as more variables had a controlled variance, the larger the VIF ratio for some independent variables. Another solution presented for the heteroskedasticity conundrum was creating a GLS regression for all countries and all maturities. The main issue is that there is an extremely large disparity in observations for some countries. This could mess linear relationships and would be difficult to compare as some smaller observations regressions scatter through specific smaller timeframes than those of larger datasets.

5. Final remarks and conclusions

This paper uses time series data from six different Eurozone countries and respective historical maturities for short-term treasury bonds. The analysis of treasury bonds is less represented in the academic literature which studies deeply longer-term auctions. In this way, treasury bonds historical values are more difficult to gather and scatter in a meaningful way.

The point of this paper is to understand the magnitude of underpricing between the secondary and primary markets. As accessibility to further discrete auction dealers price behavior proved to be difficult, further control variables were included in the regressions in an attempt to justify the price differential between both markets and to represent macroeconomic factors that can affect the prices' gap differently.

The regressions results main findings are the importance intra-bank rates such as the Euribor can have across different auction types and markets. Furthermore, primary market dealers appear to be more likely to react to macroeconomic factors such as Debt to GDP or announced issue value prior to the auction date. The evidence suggests that different auction types pose almost no difference to underpricing values. Nonetheless, there is statistical confirmation that uniform-price auctions present less significant variables, though this can be related to the fact that sampled uniform-price auctions countries presented either to small observations or high volatility in yield values (as is the case of Ireland and Greece, respectively). Finally, stronger Eurozone countries appear to have a stable demand level even in more uncertain economic periods and are the preferred choice in a more pronounced way for secondary market investors than to primary market dealers.

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Appendix A. Further analysis for the Eurozone sample:

This paper focuses on empirical analysis amongst countries of the Euro Area, making it easier to compare the spread with a funding rate practiced by the European Central Bank (ECB). The gathering of all databases for the cross-country analysis has shown the singularity exists in countries that integrate in the same financial system with a common currency. Some adaptations were necessary to be done in order to create a comparable dataframe amongst countries. Some of the regression's variables work as proxies of others; in order to use the same regressions for all auction types, some variables were compromised to set a common ground. The final regression still accounts for all the main factors that can affect the magnitude difference in the price spread.

Literature Review

-Price auctions differences

A meaningful amount of research has been done asserting which type of auction is preferable to both the issuers, as to the bidders. Amongst Western auctions, the vast majority of bidders is more inclined to choose uniform price auctions (UPA) in a survey conducted in 2004 and 2005 (Menachem Brenner et al. 2008). This preference prevails in all sampled countries and is more common as a preferred choice in all different levels of education (with Undergraduates as the lowest and Executive MBAs as the Highest). The only statistically significant difference lies in the asymmetric preference when comparing different ranges of work experience. Those with more years working with financial auctions are more prone to choose a UPA. There are papers, such as Friedman (1960) that support evidence that relates to a bigger amount of revenue generated for the issuers in UPA. Moreover, there are further recent research papers that reach that conclusion with some statistical significance. Nevertheless, what can relate to this difference in revenue is the large number of bidders UPAs can generate when placed against DPAs. Further research also suggests that even though there is a strong historical

relation between UPAs and revenues, there are still metrics that cause DPAs to be more adhered to by a large sample of countries. Mainly, when there is market uncertainty or a suggestion of low demand (seen in, for instance, lower bid-to-cover ratios), discriminatory auctions prevail as a more stable and successful type of auction. For these reasons, revenue maximization might not be the exact strategy followed by issuers (Zoltán Monostori, 2014). Another suggestion by this prevailing usage of DPAs raises the relation between more common adherence to discriminatory in less developed financial markets. This event occurs by suggestion in Brenner (Menachem Brenner et al. 2011), when countries have markets controlled by a small number of large financial institutions. These institutions benefit by having better access to information and control the level of prices between them, avoiding the "winner's curse" than can be present in DPAs.

Historical Background and Price Differential Analysis

Let's analyze the historic time of events for the Portuguese economy during this period. Unlike other economies that suffered with the European Debt Crisis, Portugal was already stagnant in the years a priori. After a strong economic expansion, the 2001 economic slowdown was covered by an increase in the deficit, which surpassed the 3% established for Eurozone members (reaching a 4.1% with prime minister António Guterres and 9.4% in 2009). The next few years there was a mist of economic uncertainty and budget deficits, despite which party was in power. Throughout the first decade of the 2000's, Portugal became poorer in real terms, growing less than the US during the Great Depression. Even though Portugal wasn't as exposed as other suffering peers, the pressure from bondholders and rating agencies created difficulties in remaining interest rates stable. In the end of 2010, bond yields reached levels so high, the Portuguese government considered the possibility of requesting a bailout package, which later

came totaling €78 billion in 2010. The requirements with the package were to follow strictly anti-cyclical Keynesian policies that brought high taxes and an increase in unemployment levels during this stabilization phase. In 2013, the ECB allowed the Portuguese sovereign debt to be converted into new bonds with delayed maturities and which meant Portugal could also issue new debt in the secondary sovereign market. The reason for these events is linked to strong capital inflows into low productivity sectors and unrealistic promises to pension holders and further, caused strong costs for the government budget which indebted the country further, as described in Ricardo Reis (2013). Since then, Portugal sovereign debt changed in the pursuit of more market competitiveness as non-competitive issues gain more weight.

In the case of Germany, being the financially strongest economy in the Euro Area, Germans' sovereign debt is directly related to that of the remaining members. Hence, when Germany is struggling financially and has an increase in their default probability, the remaining members of the Euro Area also are likely to struggle. During the 2008 financial crisis, Germany implemented a Federal Agency responsible for the financial market stabilization, which redirected risky assets from bad banks, solidifying trust in their market. Still, most German Banks showed a strong level of leverage, which suggested a higher openness to risk. Germany showed swift reaction by regulating deeper all exposed positions and by maintaining a positive government budget during the 2007-09 period. However, Germany gathered a total of €500 billion in aid to all indebted members of the Euro Area during this period. This brought trust to the EURO, although at the cost of the German economic growth.

France has shown a similar period performance as did Germany. *Per contra*, French current political instability and the increased level of indebtedness, places an otherwise European economic powerhouse, in a default risk as were all Southern Euro economies during the Sovereign Debt Crisis. France has accumulated the largest level of public debt since the Euro was implemented. Recently, and with worries of the political landscape collapse, French 10-

year bond yield has surpassed that of the Greek 10-year bond yield for the first time. This means larger borrowing costs, that for one of the most frequent issuers since 2016, in the Eurozone, can show to be problematic.

Spain eventually did apply for a €100 billion aid package from the EU, which came from a housing bubble for which the Spanish government was not prepared for, as most of the state budget revenues came from housing taxes, such as the property tax, which collapsed in value after the bubble burst in late 2012. Spain has presented recently higher GDP growth than some aiding countries such as Germany and has a stable level of public debt that rating agencies label to be of a stable and positive level (in the midst of A- and A).

Ireland Bank's suffered solvency issues due to their exposure to US real estate assets. For that reason, the Irish government resorted to a similar aid package provided by the EU and the IMF to similar austerity measures as they did to other state members. Unlike some other aided countries, Ireland complied to the policy requirements and was able to establish the state budget to satisfactory levels. Ireland peaked the level of debt during the years 2011 and 2012, but since then it was able to reduce it to 43% of debt to GDP and with one of the highest growing countries of the European Union. Sovereign bonds evolved from a B rating in 2011 to a AA in 2024 by rating agencies (mainly Moodie's and S&P), which serves as a representation of how Ireland has changed their debt structure to one of the "cleanest".

Greece was and is the most affected country by the austerity measures. Firstly, their entrance into the EU directly violated the Maastricht treaty as their Debt-to-GDP noticeably surpassed the 60% required rate. Constant economic stagnation compensated by large deficits to stimulate the economy whilst facing record unemployment growth severed the problem even further. Even though other "TROIKA" countries eventually rebounded from their sovereign risk of default, Greece is still with a lot of recover to do which was severed during the pandemic where financial aid packages were prepared to bounce back economic growth. One former finance

minister, Yanis Varoufakis wrote in his book “Adults in the room” how from early on EU and IMF representatives recognized the ineffectiveness of austerity measures in the Greece case. Greece stopped issuing 12-month bonds and only in 2018 did it reissued this maturity. Recently, Debt-to-GDP in Greece still sits in the 200% value, proving the little evolution the country had, as seen in its particular regression results.

Table 1: Sampled countries description (Part 1)

Countries	**Denomination**	**3-month**	**6-month**	**12-month**	**Comp Nominal**	**Non-comp Nominal**
France	BTFs	746 obs.	759 obs.	703 obs.	€1.000.000	(-)
Spain	Letras	149 obs.	151 obs.	144 obs.	€1.000	€1.000
Portugal	BTs	54	71	106	€1.000.000	€1.000
Germany	Bulbills	(-)	192 obs.	184 obs.	€1.000.000	(-)
Ireland	ITBs	(-)	29 obs.	14 obs.	€100.000	€100.000
Greece	T-Bills	155 obs.	159 obs.	(-)	(-)	(-)

Table 2: Sampled countries description (Part 2)

Countries	**Bids Minimum**	**Days Settlement**	**Monthly Frequency**	**Time Frame**	**Auction Type**
France	10 bp	2 days	4/month	2010/2024	discriminatory
Spain	(-)	3 days	2/month	2013/2024	multi-unit
Portugal	(-)	2 days	2/month	2011/2024	discriminatory
Germany	0.005 bp	2 days	4/month	2008/2024	discriminatory
Ireland	(-)	2 days	(-)	2016/2022	uniform
Greece	(-)	2 days	(-)	2011/2024	uniform

Notes:
Notes: Both market prices are computed as

$$DV = \frac{NV}{1 + \left(\frac{i}{100} \times \frac{n}{360}\right)}$$

, n represents the number of days between the settlement and maturity date and i is the marginal yield representative for a given auction as the last accepted. n is fixed for both the primary as for the secondary markets to avoid misalignments. Moreover, some datasets presented a wide range of days for same maturities which complicated time-series analysis but proved interesting to compare underpricings based on yield demand levels. Further explaining the Spanish auction for *Letras del Tesoro*, the auction selection starts as a uniform-price auction, but as the desired level of issuance is approximated, the auction switches to discriminatory selection.

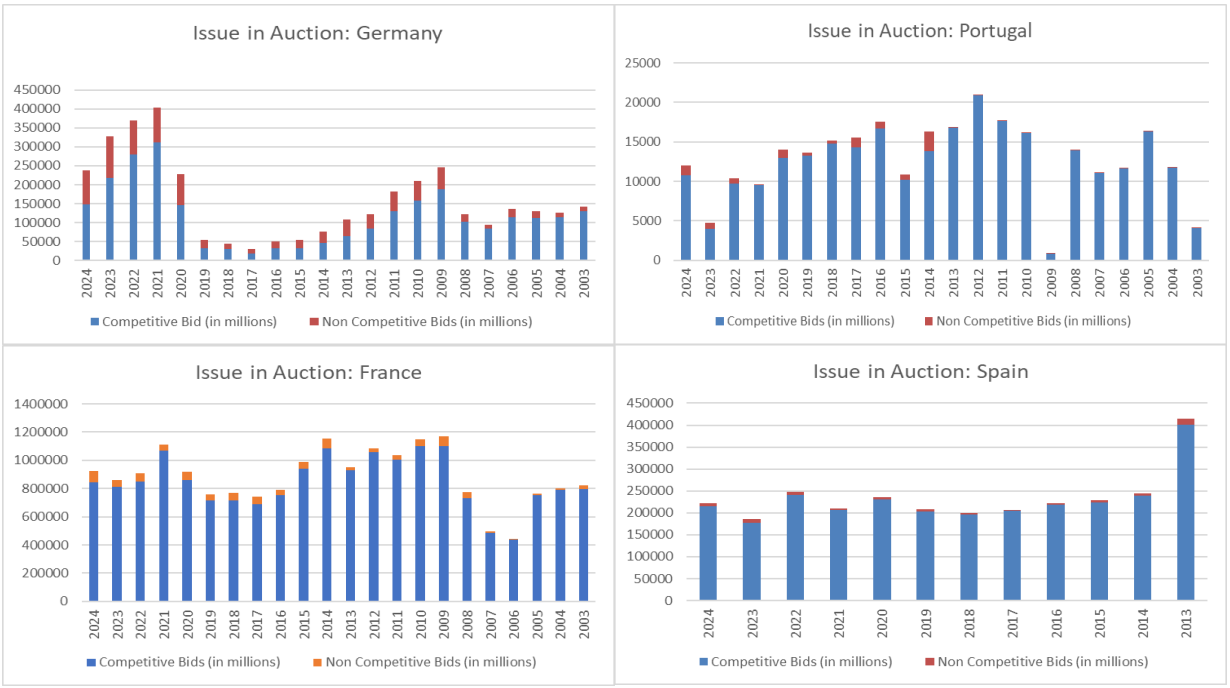


Figure 1 Issuance discriminated per phase.

"Bilhetes de Tesouro" have changed their volume over the years without any significant rate of change, although the weight of non-competitive allotment issued during the last 21 years has increased. This suggests a larger demand and more issuance of sovereign debt for smaller investors in the primary market (bid is tranched in €1.000.000 for competitive and €1.000 for noncompetitive).

As for Bulbills, one can reflect the drastic change in their short-term primary market issuance. The most pronounced issuance periods are during the European Sovereign Crisis and during the pandemic financial package that intended to aid the German and EU state members recovering from the economic slowdown. Nevertheless, a more pronounced trend has begun in the weight of non-competitive phases has in the overall allotment of bonds by the issuers.

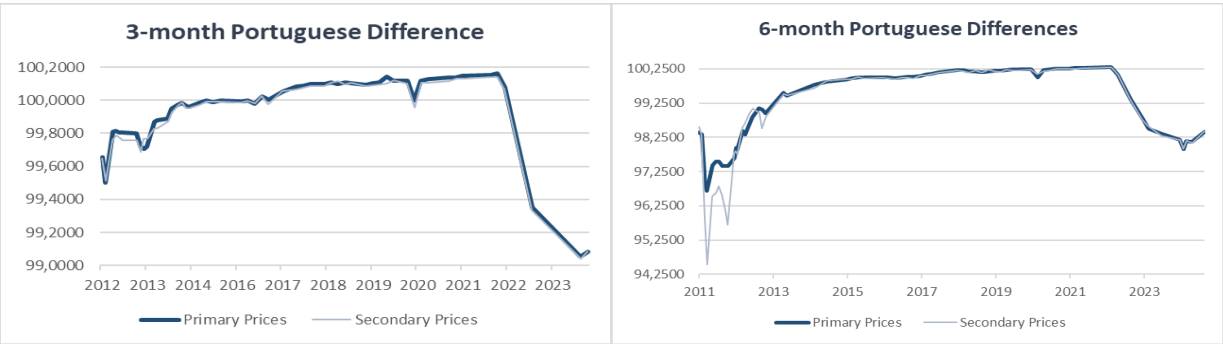
BTFs have a diminished relative presence of non-competitive bids. Although when competitive phases show an expansion, there is a correlated increase by non-competitive allocations for bidders. Nevertheless, the meaningfulness of non-competitive bids is still small when compared to other hegemonic economies such as Germany.

Letras del Tesoro showed unusual levels of competitive bids during the post sovereign debt crisis of Spain, and as for the remaining countries, a larger non-competitive presence. Nevertheless, for the remaining following years, the level remained relatively stable, even throughout the pandemic period.

In sum, Germany shows the highest level of presence in the non-competitive auction in a much more pronounced way than that of the remaining sample. Even though Portugal was the one that increased the most in the remaining countries, the level of competitiveness amongst elected investors and smaller ones is clearly larger in Germany sovereign debt auctions in a historic way. Greece does not distinguish between both auction phases and Ireland lacks a large enough timeframe and a reasonable sample size to be represented here.

Another extremely relevant metric is the Stop Price scattered for all years in a comparable sample. Considering the size of the sample for each maturity, the model will mainly consider maturities of 3, 6 and 12 months. Now, as auctions rarely follow any predictable date, the Prices from the sample are not completely line-in-line for all maturities, presenting more consistent values in an asymmetrical plot. For most of the sampled countries, the start of the spillover effects of the 2008 financial crisis and subsequent TROIKA intervention saw a restriction in the indicative amount per auction (debt emission amount). Between 2009 and 2021, CPI was leveled below the 2% mark with some years of deflation.

Hence, let's have a look into how the price behavior is actually like for Portugal:



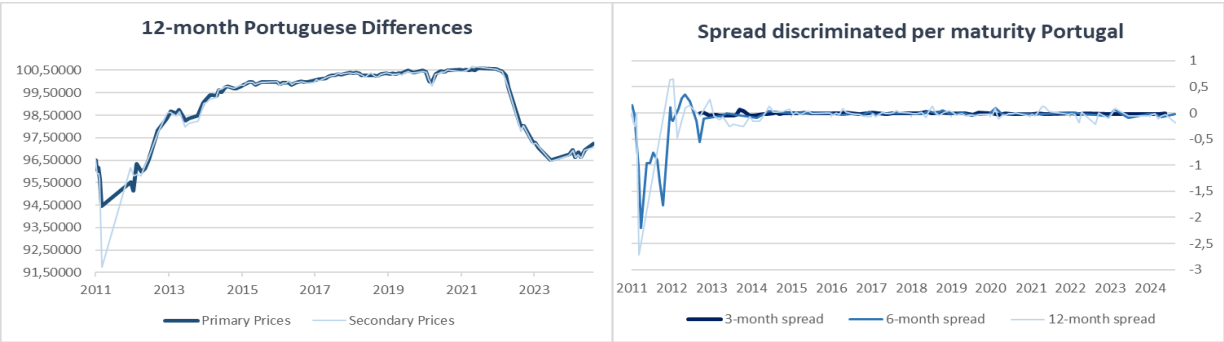
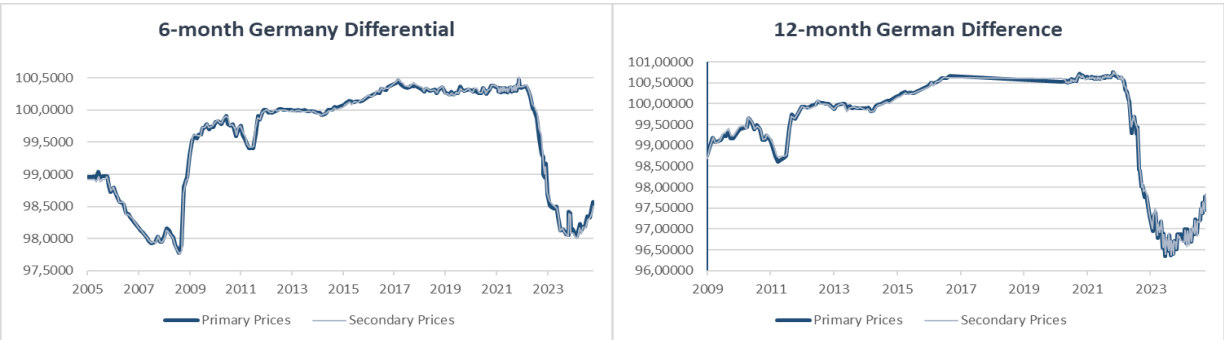


Figure 2 Portugal Price Differential.

The 3-month and 6-month maturity price differences both have a strong correlation throughout the presented timeframe. However, it is clear that during the early 2010's, Portugal sovereign debt suffered high levels of default risk, suggested by the low-priced securities. Contrasting to this, even though the debt uncertainty from the 12-month secondary market is seen in the early 2010's, there was a downgrade in the price of the primary market bonds although with some more stability than that of the secondary one. This behavior follows the theoretical sense explored in (John Beirne et al. 2011), where the level of stability between both markets is explored concluding to more pronounced uncertainty, seen in the form of high short-term volatility.



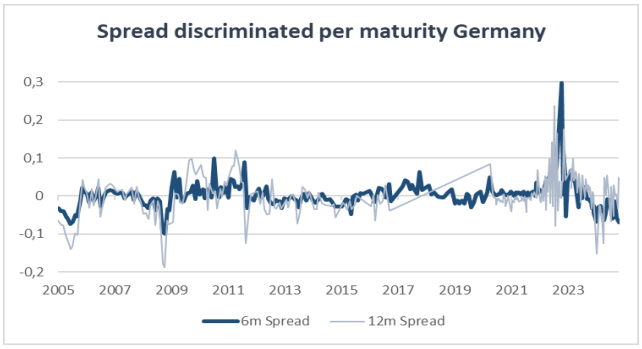


Figure 3 Germany Price Differential.

As already stated, the 6-month maturity scatters through a more prolonged time frame than the 12 month one, carrying a larger sample. Nevertheless, the price behavior on both markets is extremely correlated and its trend during both timeframes is almost identical. Negative rates were prolonged during nearly a decade of slow economic activity for both maturities. Contrary to Portugal, Germany bonds of the 6-month and 12-month maturities have a statistically similar trend which elevates the reasoning that cross-country samples present different and sometimes contrasting results. As for spreads for both maturities, the 12-month spread timeframe between 2017 and 2020 has scarce sample data which can create differences in comparison. However, the defining feature of both spreads is the frequency with which the spread skews towards negative values. This spread suggests that the pricing of the secondary market may sometimes underprice that of the primary market. One can suggest the level of demand in the secondary market is suppressed by that of the primary market to the point where the primary market pricing becomes overpriced for primary market bond holders. Nevertheless, the extreme values presented during this period are still relatively close as the largest differential registered was larger than -0,2 percentage points.

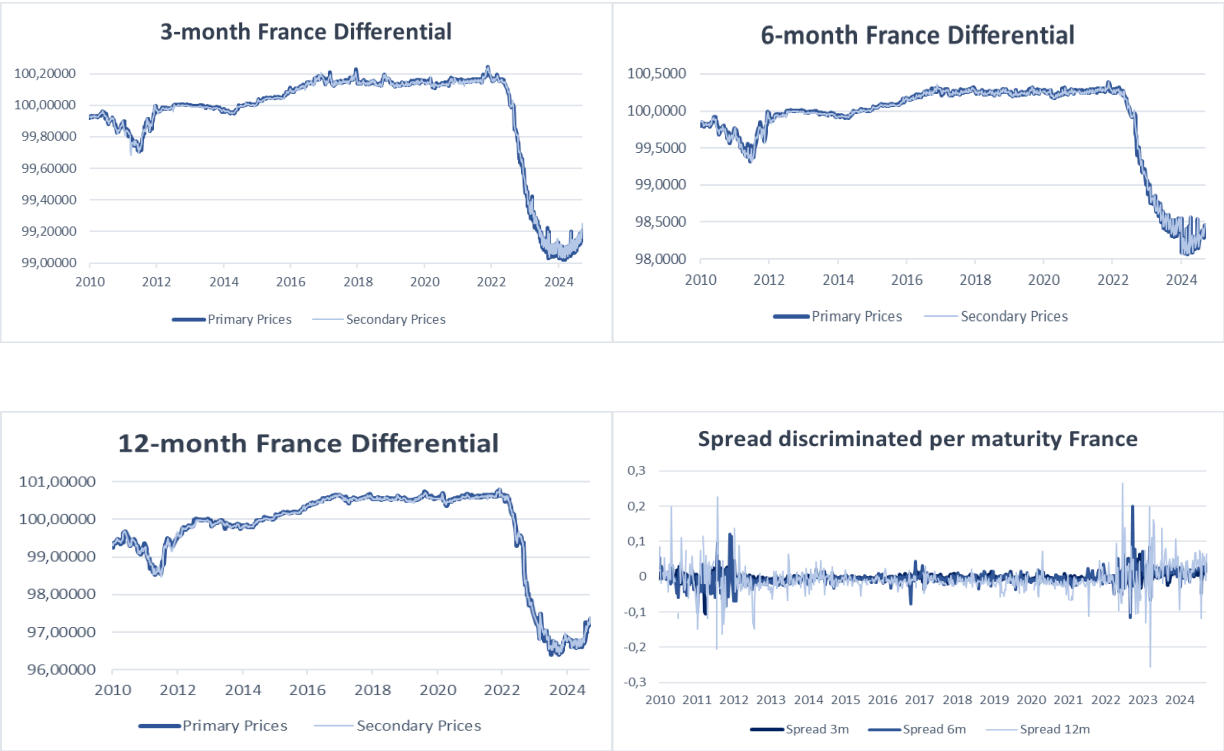
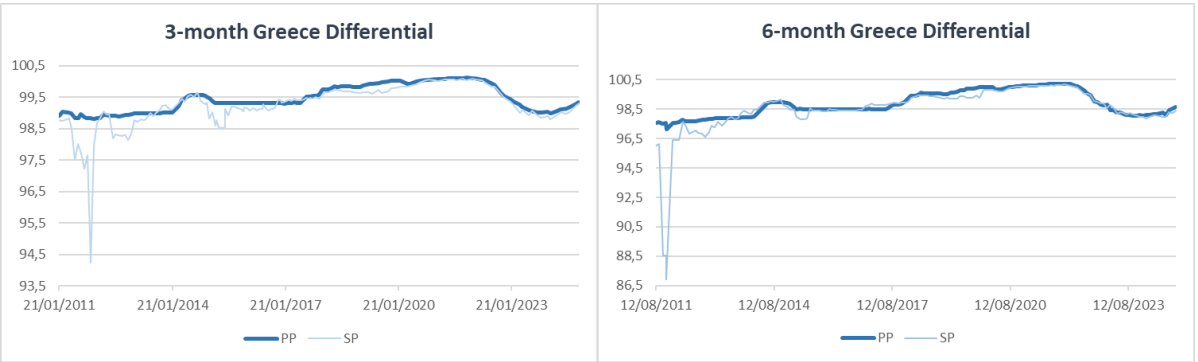


Figure 4 France Price Differential.

France is from all the sampled countries, one of the most volatile yet controlled price differential. Clearly, there is evidence of both underpricing and overpricing in all three maturities, even if in a more pronounced way in the 12-month sovereign bonds. As for the three maturities, as France presents a strong number of auctions throughout the years, any price differential is almost unnoticeable. For context, the largest price differential in the 12-month maturity is +0,2645 underpricing from a primary market bond (i.e., the secondary market bond price for the same period, surpasses the primary market one by +0,2645) and for the second largest is merely +0,227. Overpricing has less magnitude but of similar values.



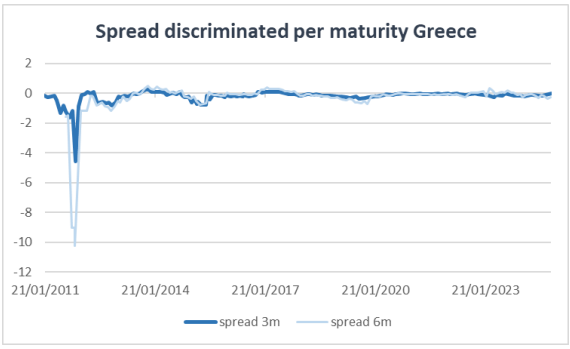


Figure 5 Greece Price Differential.

Moments of underpricing are rare and occur only during the periods of 2014-2016 and slightly before the pandemic. Theoretically, the primary dealers normally suffer losses as most moments between the secondary and primary markets are normally negative. Nevertheless, the largest primary dealers keep purchasing due to representing banks and other Greek institutions that could risk further exposure if the Greece primary market demand or default risk deteriorated further. As seen in the spread graph, during middle 2012 Greece presented their largest overpricing to date achieving a price difference of over 10 points between the primary and secondary market just for the 6-month maturity. Even the 3-month maturity also showed a large shift and since then, the spread remained similar to that of the 6-month maturity.

Spain and Ireland are not represented both by sample size reasons and graphic constraints.

Discriminated countries catalog:

Here is a resumed side note that intends to report a brief description of the quality of each Euro Area country, providing a reasonable insight into the choice of each country used in this paper.

Austria- Provides the auction results until 2020, which comprises a total of 84 auctions of short-term maturities. All variables required for the primary market are present, proposing an interesting country to include in the sample. However, the scale of the provided historical values is undermining.

Belgium- The treasury certificates offer short-term bonds. Nevertheless, the Belgium Debt Agency also issues Euro Commercial Paper. The number of yearly auctions extend until 1998, but the yearly frequency is sub-par when compared to the remaining peers. Furthermore, the auction results are provided in the form of a pdf, which prolonged difficulties gathering all materials without any variable deformation.

Croatia- Offers a complete database from 2005 until 2024, included with all required variables of the primary market. Unfortunately, Croatia only officially joined the Eurozone in 2023, creating the comparison with all remaining countries and the usage of the EU funding rate for the spread of the dependent variable a problematic scenario.

Cyprus- Treasury bills issued are only 13 weeks long and average around 10 auctions per year. The variables for the primary market are relevant and have a timeframe long enough to be interesting to apply to the regression. However, Cyprus auction results are sometimes presented in pdf format, complicating the access to all variables.

Estonia- Treasury are of a small size and timeframe to be moldable into the regression. Furthermore, the public available data lacks relevant variables.

Finland- Finland's database prolongs into a relevant timeframe. A lot of the issuances are labeled "other issuances", meaning the outstanding amounts of bonds issued in an auction are fairly small and are only registered from 2021 beyond.

Greece- Offers some required primary market variables, lacking discrete variables for different auction phases comparisons. It has a stable sample for all maturities except the 12-month maturity. It only offers 30 auctions between 2020 forward.

Ireland- Offers a small but complete sample for the primary market auction results.

Italy- Sizable sample, however, all auction results are in a pdf format and in a unitary form. There is an available historical excel but only gathers the nominal yield and the allotment made in the issuance of bonds.

Latvia- All auctions are presented in unitary pdf. It is unfeasible to gather data samples.

Malta- All auctions are presented in unitary pdf. It is unfeasible to gather data samples.

Slovakia- All auctions are presented in unitary pdf. It is unfeasible to gather data samples.

Slovenia- All auctions are presented in unitary pdf. It is unfeasible to gather data samples.

Appendix B: Regression Results and Statistical Tests

Table 1: Regression Results and Statistical Tests

Regression	Breusch-Pagan	White	VIF
France 3-month	Rej*	Rej***	2.93
France 6-month	Rej***	Rej**	1.49
France 12-month	Non Rej	Rej**	1.17
Spain 3-month	Rej***	Rej***	1.95
Spain 6-month	Rej**	Rej***	2.21
Spain 12-month	Rej**	Rej***	2.12
Portugal 3-month	Non Rej	Non Rej	1.82
Portugal 6-month	Rej*	Rej*	1.45
Portugal 12-month	Non Rej	Rej*	1.28
Greece 3-month	Rej*	Rej***	1.34
Greece 6-month	Rej***	Rej***	1.37
Ireland 6-month	Non Rej	Non Rej	1.74
Ireland 12-month	Non Rej	Non Rej	1.57
Germany 6-month	Non Rej	Rej**	1.64
Germany 12-month	Non Rej	Rej**	1.52

Notes: Rej and Non Rej refer to the null hypothesis of existing homoskedasticity in the regression. If rejected, it means that at a certain statistical significance, it is possible to reject homoskedasticity, which in turn means there is possible heteroskedasticity presence. *, **, ** denote significance at the 10%, 5% and 1%, respectively. VIF represents the average VIF of all used variables of any particular regression

Correlation Matrixes:

Germany

	UNDERP	COVER_~R	log_IS~E	OUTSEC	rel_DEBT	rel_EU~R	rel_YL~R	HIGHVOL
UNDERP	1.0000							
COVER_SMAL~R	-0.1460	1.0000						
log_ISSUES~E	0.1950	-0.4252	1.0000					
OUTSEC	0.2216	-0.1030	0.1531	1.0000				
rel_DEBT	0.0443	0.0318	0.4029	-0.0234	1.0000			
rel_EURIBOR	-0.3921	0.0887	-0.0450	0.3381	-0.1761	1.0000		
rel_YLDCUR	0.1718	-0.0860	0.5118	-0.0589	0.6836	-0.3667	1.0000	
HIGHVOL	0.2003	-0.0146	0.2226	0.2106	0.0747	-0.0413	0.1484	1.0000

	UNDERP	COVER_~R	log_IS~E	OUTSEC	HIGHVOL	rel_DEBT	rel_EU~R	rel_YL~R
UNDERP	1.0000							
COVER_SMAL~R	-0.2398	1.0000						
log_ISSUES~E	0.1534	-0.4421	1.0000					
OUTSEC	0.0544	-0.1707	0.2166	1.0000				
HIGHVOL	0.0085	-0.1014	0.1384	0.1327	1.0000			
rel_DEBT	0.1092	0.1134	-0.1223	-0.2609	-0.0047	1.0000		
rel_EURIBOR	-0.3429	0.1401	0.0960	0.3167	-0.1917	-0.4810	1.0000	
rel_YLDCUR	0.2141	-0.0566	0.0531	-0.1476	0.1746	0.8113	-0.4925	1.0000

Figure 6 Germany 6 and 12-month Correlation Matrix.

Ireland

	UNDERP	COVER	PRORAT	log_IS~E	rel_YL~R	rel_EU~R	SMALPAR	OUTSEC
UNDERP	1.0000							
COVER	-0.5012	1.0000						
PRORAT	0.2481	-0.1971	1.0000					
log_ISSUES~E	0.1224	-0.1491	0.4727	1.0000				
rel_YLDCUR	0.6657	-0.5347	0.0880	0.3025	1.0000			
rel_EURIBOR	-0.1842	-0.1841	0.1942	0.0775	0.1601	1.0000		
SMALPAR	0.2024	-0.1496	0.0622	0.0576	-0.0950	-0.1505	1.0000	
OUTSEC	0.2954	-0.2875	-0.0671	0.1275	0.6405	0.4578	-0.1322	1.0000

	UNDERP	SMALPAR	OUTSEC	rel_DEBT	rel_EU~R
UNDERP	1.0000				
SMALPAR	-0.6161	1.0000			
OUTSEC	-0.6464	0.6142	1.0000		
rel_DEBT	0.0920	0.2540	0.3577	1.0000	
rel_EURIBOR	0.5850	-0.2194	-0.4859	-0.1191	1.0000

Figure 7 Ireland 6 and 12-month Correlation Matrix.

Portugal

	UNDERP	COVER	log_IS~E	OUTSEC	rel_DEBT	rel_EU~R	rel_YL~R
UNDERP	1.0000						
COVER	-0.1818	1.0000					
log_ISSUES~E	-0.1942	0.3081	1.0000				
OUTSEC	-0.3312	0.1133	0.4592	1.0000			
rel_DEBT	-0.0208	0.1964	-0.0445	0.1048	1.0000		
rel_EURIBOR	-0.0873	-0.2299	0.1242	0.0742	-0.6924	1.0000	
rel_YLDCUR	0.0367	0.3253	0.1962	0.2736	0.6301	-0.3824	1.0000

	slog_U~P	COVER	log_IS~E	OUTSEC	rel_DEBT	rel_YL~R
slog_UNDERP	1.0000					
COVER	-0.2642	1.0000				
log_ISSUES~E	0.4238	-0.2923	1.0000			
OUTSEC	-0.7775	0.1472	-0.4017	1.0000		
rel_DEBT	0.2447	-0.1731	0.3295	-0.3410	1.0000	
rel_YLDCUR	0.7124	-0.2301	0.3447	-0.5732	0.4712	1.0000

	slog_U~P	SMALPAR	COVER	OUTSEC	log_IS~E	rel_D~IT	rel_YL~R
slog_UNDERP	1.0000						
SMALPAR	-0.0522	1.0000					
COVER	-0.0083	0.3524	1.0000				
OUTSEC	-0.2375	0.2267	0.2022	1.0000			
log_ISSUES~E	0.1071	-0.0249	-0.0858	0.0622	1.0000		
rel_DEFICIT	-0.1370	-0.2434	0.0376	-0.0419	0.0547	1.0000	
rel_YLDCUR	0.0744	0.1298	-0.3107	-0.1190	0.0476	-0.4687	1.0000

Figure 8 Portugal 3, 6 and 12-month Correlation Matrix.

Greece

	slog_U~P	COVER_~T	log_IS~E	OUTSEC	rel_IM~L	rel_DEBT	rel_YL~R
slog_UNDERP	1.0000						
COVER_PRORAT	-0.0555	1.0000					
log_ISSUES~E	-0.1666	0.2713	1.0000				
OUTSEC	-0.6590	0.0335	0.1386	1.0000			
rel_IMPVOL	-0.4318	0.1149	0.1102	0.3543	1.0000		
rel_DEBT	0.2791	0.1690	-0.3714	-0.1526	-0.0914	1.0000	
rel_YLDCUR	0.2042	-0.0794	-0.3912	-0.2293	-0.1938	0.4969	1.0000

	slog_U~P	rel_DEBT	rel_EU~R	log_IS~E	OUTSEC	HIGHVOL	COVER
slog_UNDERP	1.0000						
rel_DEBT	0.2518	1.0000					
rel_EURIBOR	-0.2450	-0.5305	1.0000				
log_ISSUES~E	-0.1575	-0.1908	-0.2511	1.0000			
OUTSEC	-0.1993	-0.2942	0.1003	0.0997	1.0000		
HIGHVOL	-0.3606	0.0442	0.0238	0.0462	0.2517	1.0000	
COVER	-0.1891	0.0112	0.0161	-0.1237	0.1748	0.0224	1.0000

Figure 9 Greece 3 and 6-month Correlation Matrix.

Spain

	UNDERP	SMALPAR	COVER	log_IS~E	OUTSEC	rel_IM~L	rel_EU~R	rel_YL~R
UNDERP	1.0000							
SMALPAR	0.0866	1.0000						
COVER	-0.0602	-0.1458	1.0000					
log_ISSUES~E	0.2620	0.3607	-0.7316	1.0000				
OUTSEC	-0.4147	0.1104	-0.1193	0.0852	1.0000			
rel_IMPVOL	0.2044	0.1716	0.0767	0.1796	0.0273	1.0000		
rel_EURIBOR	-0.5436	0.0356	-0.0401	-0.1099	0.3658	-0.1616	1.0000	
rel_YLDCUR	0.4662	0.0818	-0.1808	0.4528	-0.1016	-0.0331	-0.4534	1.0000

	slog_U~P	SMALPAR	COVER	log_IS~E	OUTSEC	rel_IM~L	rel_EU~R	rel_YL~R
slog_UNDERP	1.0000							
SMALPAR	-0.1592	1.0000						
COVER	0.1783	-0.2336	1.0000					
log_ISSUES~E	-0.0102	0.5197	-0.7271	1.0000				
OUTSEC	-0.0550	0.1737	-0.2494	0.3742	1.0000			
rel_IMPVOL	0.2463	0.1711	0.0941	0.1006	0.0656	1.0000		
rel_EURIBOR	-0.5736	0.1853	-0.3177	0.1901	0.3123	-0.2146	1.0000	
rel_YLDCUR	0.3938	0.0634	0.1811	0.1187	-0.0631	-0.0687	-0.5838	1.0000

	slog_U~P	SMALPAR	COVER	log_IS~E	OUTSEC	rel_IM~L	rel_EU~R	rel_YL~R	rel_DEBT	rel_D~IT
slog_UNDERP	1.0000									
SMALPAR	-0.3205	1.0000								
COVER	0.2667	-0.1688	1.0000							
log_ISSUES~E	-0.2774	0.3303	-0.5740	1.0000						
OUTSEC	-0.0402	0.3297	0.0868	-0.1551	1.0000					
rel_IMPVOL	0.1964	0.0369	0.0556	0.0218	0.1959	1.0000				
rel_EURIBOR	-0.5248	0.3520	-0.2835	0.0635	0.2611	-0.2265	1.0000			
rel_YLDCUR	0.2872	-0.1695	0.2257	-0.2406	0.0258	-0.0207	-0.6061	1.0000		
rel_DEBT	0.0850	-0.0267	0.0785	0.1393	0.0387	0.3143	0.0207	-0.4600	1.0000	
rel_DEFICIT	-0.0493	0.0182	-0.2366	0.0367	-0.0902	-0.2232	0.3112	-0.3390	-0.3601	1.0000

Figure 10 Spain 3, 6 and 12-month Correlation Matrix.

France

	slog_U~P	SMALPAR	COVER	PRORAT	log_IS~E	OUTSEC	HIGHVOL	DEBT	DEFICIT	YLDCUR
slog_UNDERP	1.0000									
SMALPAR	0.2956	1.0000								
COVER	-0.0022	0.2512	1.0000							
PRORAT	0.0769	0.0042	-0.8972	1.0000						
log_ISSUES~E	0.0662	-0.0162	-0.3460	0.2398	1.0000					
OUTSEC	-0.0110	0.0422	-0.1386	0.1796	-0.0464	1.0000				
HIGHVOL	0.0398	-0.0063	-0.1348	0.1359	0.1311	0.1052	1.0000			
DEBT	0.1053	0.1215	0.2391	-0.1583	-0.5121	0.0801	-0.0808	1.0000		
DEFICIT	0.0979	0.0537	-0.2497	0.2259	-0.1033	-0.0274	-0.1072	-0.1639	1.0000	
YLDCUR	-0.0344	-0.0982	-0.0843	0.0298	0.2449	-0.1482	-0.0129	-0.2977	0.3048	1.0000

	slog_U~P	SMALPAR	COVER	log_IS~E	OUTSEC	rel_IM~L	HIGHVOL	rel_DEBT	rel_EU~R
slog_UNDERP	1.0000								
SMALPAR	0.3422	1.0000							
COVER	0.0293	0.1437	1.0000						
log_ISSUES~E	-0.0176	-0.0464	-0.5102	1.0000					
OUTSEC	0.1311	0.0803	-0.0352	-0.0064	1.0000				
rel_IMPVOL	0.0303	0.0120	-0.1206	0.1394	0.2445	1.0000			
HIGHVOL	0.0715	0.0171	-0.0891	0.0405	0.2039	0.7292	1.0000		
rel_DEBT	0.1193	0.1583	0.1587	-0.2061	0.1069	-0.1034	-0.0548	1.0000	
rel_EURIBOR	-0.1001	0.0503	-0.0098	0.0090	0.2621	-0.1627	-0.0823	0.2777	1.0000

	slog_U~P	SMALPAR	PRORAT	log_IS~E	HIGHVOL	rel_DEBT	rel_EU~R
slog_UNDERP	1.0000						
SMALPAR	0.3768	1.0000					
PRORAT	-0.0446	0.0884	1.0000				
log_ISSUES~E	-0.0140	-0.0410	0.4289	1.0000			
HIGHVOL	0.0720	0.0019	0.0765	0.0616	1.0000		
rel_DEBT	0.0251	0.1971	-0.0458	-0.1245	-0.0158	1.0000	
rel_EURIBOR	-0.0975	0.1355	0.1363	0.2102	-0.0796	0.2897	1.0000

Figure 11 France 3, 6 and 12-month Correlation Matrix.