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ABSTRACT

Price Effects of Sovereign Debt Auctions in the Euro-zone: The Role of the Crisis*

Exploring the period since the inception of the euro, we show that secondary-market yields on Italian public debt increase in anticipation of auctions of new issues and decrease after the auction, while no or a smaller such effect is present for German public debt. However, these yield movements on the Italian debt are largely confined to the period of the crisis since mid-2007. We also find that there is some tendency of the yield movements to be larger when the demand for the new issue is smaller relative to its supply. Our results are consistent with a framework in which a small group of primary dealers require compensation for inventory risk and this compensation needs to be higher when market uncertainty is larger. We also find that the secondary-market behaviour of series with a maturity close to the auctioned series, but for which there is no auction, is very similar to the secondary-market behaviour of the auctioned series. These findings support an explanation of yield movements based on the behaviour of primary dealers with limited risk-bearing capacity.

JEL Classification: G12 and G18
Keywords: auctions, bid-to-cover ratio, crisis, euro-zone, event study, Germany, Italy, primary dealers, public debt and yield movements

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1. Introduction

Auctions are important events in the treasury bond market, but their timing and size are typically known several days in advance. In an efficient market, one would therefore expect no predictable bond price or yield movements around auctions.[1] Nevertheless, recent empirical research (Fleming and Rosenberg, 2007, and Lou, Yan and Zhang, 2013) has documented the existence of an 'auction cycle' in treasury bond yields. There is an inverted V-shaped pattern in bond yields around auctions, starting three to five days before the auction. Yields revert to their original level again three to five days after the auction. In this paper, we offer new evidence on the existence of an auction cycle in the secondary markets for public debt and explore the impact of the economic and financial crisis on the magnitude of the auction cycle. We select two countries, Germany and Italy, for which public debt yields have been clearly affected by the debt crisis, but in substantially different ways, with German yields falling to unprecedentedly low levels and Italian yields rising to dangerously high levels. For these countries, we compare the responses of secondary-market yields for different sample periods, in particular distinguishing the periods before and after the start of the global financial and economic crisis in 2007. We also select sub-samples covering periods during which the euro zone debt crisis was relatively intense.

We focus on a particular theoretical explanation for the existence of the auction cycle, namely the inventory management operations of the primary dealers. These dealers absorb the bulk of the new bond issue, but it takes some time for them to distribute the newly issued bonds to their customers. In the meantime, the primary dealers run the risk of price fluctuations on their inventory of auctioned bonds. To compensate for this risk, they bid down the price of the bonds (and bid up the yields) in the days around the auction. Hence, despite the predictability of bond auctions, inventory management by the primary dealers leads to predictable (but temporary) price patterns. This theory has a number of testable predictions. A first prediction is that if primary dealers face a more risky market, they will charge higher markups and we expect the auction cycle to be stronger. We therefore expect that the auction cycle is stronger in crisis periods with a lot of uncertainty. Primary dealers make the market in bonds of a variety of maturities. A second prediction of the theory therefore is that an auction

[1] Of course, the announcement of the auction result may move the market in so far as the outcome was unexpected, see Fleming and Remolona (1997).

also puts pressure on the yields of bonds with maturities close to the auctioned maturity. Again, this effect is expected to be stronger in crisis periods.

Our results are strongly in line with those predictions. Secondary-market yields on Italian public debt increase in anticipation of a new debt auction and decrease after the auction, while no or smaller such an effect is present for German public debt. The yield movements on the Italian debt are largely concentrated in the period of the crisis since mid-2007, while there is only limited movement in the period before the crisis. The fact that yield movements during the run-up to an auction tend to be fully reversed after the auction suggests that the observed yield movements are not driven by long-term supply effects. Our empirical analysis also establishes that the secondary-market behaviour of series for which there is *no* auction but with a maturity close to that of the auctioned series is very similar to the secondary-market behaviour of the auctioned series. This particular finding supports our theory of yield movements being driven by the behaviour of primary dealers with limited risk-bearing capacity over other explanations based on liquidity effects of switching benchmark securities. Splitting the period since mid-2007 further, we find even stronger Italian yield movements for the sub-period since September 2009, the period characterised by the European debt crisis. In addition, for the period since mid-2007, we find that the auction-related yield movements are larger when the intensity of the crisis is stronger as measured by relevant proxy variables. Hence, all our evidence taken together suggests that economic and financial turbulence has important effects on how sovereign yields move around dates of debt auctions by vulnerable countries.

The reason for selecting Germany and Italy is that these are large economies that have substantial amounts of public debt outstanding.[2] Hence, the markets in their public debt are among the most liquid and active of the euro-zone. The auction mechanisms used in these countries are also slightly different. Italy always sells the full amount, but Germany sometimes withholds some bonds if demand is low. If the issuer can mitigate quantity or price risk in the auction, the auction cycle can possibly be mitigated too. We therefore also perform a regression analysis that allows exploring the effects of the issuance volume of the auctions and the bid-to-cover ratio. The results show that yield movements tend to be larger when the auction size is large and when the bid-to-cover ratio is small. Splitting the Italian crisis sample

[2] At the end of December 2012, the total Italian public debt was €1,990 billion (of which €1,640 billion of outstanding bonds), while the German public debt was €1,139 billion.

into auctions that went well or badly in terms of bid-to-cover ratio, we find that for the latter the marginal positive effect of a lower bid-to-cover ratio on yields is larger.

We present two practical applications of our analysis. First, exploiting the relationship between secondary-market yields and yields at which new debt is auctioned, we can establish that the issuance cost has increased substantially between the pre-crisis and the crisis period. Over its entire life this increase for an Italian five-year bond issue is estimated at around 10 million euro's. This figure is based on the entire second sub-period and, given that the degree of crisis intensity has fluctuated substantially over this sub-period, it likely constitutes a lower bound on the effects that a really deep crisis may have. In a second application, we assess the opportunities for market participants to profitably exploit the yield movements around auctions. An evaluation based on Sharpe ratios suggests that these yield movements are not sufficiently large to profitably overcome the transactions costs associated with the additional trading and the tendency of the market volatility to increase during the run-up of auctions. Nevertheless, there may be timing opportunities for parties that for exogenous reasons have to trade.

The remainder of this article is structured as follows. Section 2 contains a brief literature review and sets out the conceptual framework for our empirical analysis. After a short description of the auction process and the dataset in Section 3, Section 4 presents the results of the event study. Section 5 contains the regression analysis, while Section 6 probes deeper into the effects of the crisis. Section 7 presents the applications. Finally, Section 8 concludes the main body of the paper.

2. Evidence from the literature and conceptual framework

2.1. Evidence from the literature on yield effects of auctions

Several papers have documented unusually high yields, relative to some benchmark, on treasury bonds during and around auctions. A first line of studies compares the average yield bid in the auction to the yield on another instrument, which at the time of the auction is almost identical to the auctioned bond. Examples of such studies are Simon (1994), Nyborg and Sundaresan (1996) and Goldreich (2007). They find a small underpricing of treasury auction securities in the order of magnitude of a 1 basis point higher yield. Recent evidence for underpricing of the auctioned bond is given by Lou *et al.* (2013). They provide some statistics on the difference between the auction yield and the on-the-run bond yield on the day of the auction. The auction yield is always higher than the on-the-run bond yield, with a difference ranging from 0.8 basis points for the 10-year maturity, 1.4 basis points for the 5-year maturity, and 2.5 basis points for the 2-year maturity.[3] A second line of literature explores yield effects in the days around the auctions. Fleming and Rosenberg (2007) study the price returns of U.S. treasury bonds on days surrounding the auctions, and relate these to the position changes of primary dealers, decomposed into a part related to auctions and a residual part. They document positive yield changes before the auction (1 to 1.5 basis points), and negative yield changes after the auction (1 to 2.5 basis points), as a result of the auction-driven position changes. They also show that the larger the position change, the larger the yield effects. Lou *et al.* (2013) empirically document that yields in the U.S. secondary market increase before auction days and decline again in the days after the auction. The effect is quite large and roughly the same for 2, 5 and 10-year maturities, namely around 2.5 basis points (in a five-day window around the auction). They also document spillovers from the 10-year bond auctions to the 5-year yield (and less so to the 2-year yield) and stronger effects in volatile periods. Forest (2012) adds to this literature by investigating the effect of bid-to-cover ratios on U.S. Treasury interest rates during the 1990s. He finds that a higher-than-expected bid-to-cover ratio, which indicates strong auction demand, tends to push the yield of 5 and 10-year Treasury notes down. Conversely, a lower ratio, indicating a weak auction demand, is associated with increased interest rates.

A closely related literature studies the effect of bond purchases under the recent Quantitative Easing Programmes of central banks in the U.S., the U.K. and the euro zone. Most of these papers explore the price effects of the announcement of the programmes (e.g. Krishnamurthy and Vissing-Jorgensen (2011) for the U.S. and Joyce *et al.* (2011) for the U.K.). However, a few papers look at price effects on and around the days of the actual bond purchases. D’Amico and King (2013) estimate the impact of the bond purchases by the U.S. Fed. Given the way the purchase programme was structured, the amount and issue purchased on specific days were known in advance, similar to the information structure in auctions. D’Amico and King detect significant price effects on the day of the purchase. For a representative 10-year bond, the yield decreases by 0.3 basis points per billion dollars purchased. The price effects on bonds with a similar maturity are almost as large, indicating a high degree of substitutability between bonds with similar maturities. The price effect is

[3] These numbers are our own calculations based on the data in Tables II and IV in Lou *et al.* (2013).

temporary and reverted within six days after the purchase. Eser and Schwaab (2013) study bond purchases by the ECB under its Securities Market Programme (SMP). In contrast to the Fed, the ECB did not announce when, how much and which bonds to purchase. They estimate a yield decrease for Italy of 1 to 2 basis points per billion purchased. Around three quarters of this initial price impact is permanent, although the authors acknowledge that the permanent effect cannot be estimated very precisely.

2.2. Potential sources of yield effects of auctions

There exist a number of factors potentially affecting yield movements during and around auctions. These yield effects could pertain to the primary market, to the secondary market, or both. First, auctions change the supply of treasury bonds. As such, there could be an effect of auctions on the interest rates on both outstanding and new debt issues. Moreover, the effect should remain for as long as the change in the supply lasts. Krishnamurty and Vissing-Jorgensen (2012) find a negative effect of the U.S. Treasury bond supply on the difference between corporate bond yields and treasury yields. *Ceteris paribus*, a doubling of the public debt-to-GDP ratio leads to a 44 basis points increase in treasury yields. Of course, any single auction can change the debt-to-GDP ratio only by a tiny fraction. For example, in our data the average auction issuance volume for Italy is between 3 and 5 billion euro, relative to a total stock of debt of 2,000 billion euros. Hence, a single auction raises the debt to GDP ratio by at most roughly 0.25% percentage points.[4] This is a very small change in the total supply and, all in all, the supply effect of an auction should have a negligible impact on yields. Obviously, to the extent that part of the debt stock is not traded but passively held by investors in their portfolios, the supply effect on prices may be magnified as the supply pressure concentrates on the much smaller part of debt that is actually traded.

Second, with the auction of a new series of a given maturity the latest issue of the same maturity goes "off-the-run", while the new series becomes the "on-the-run" series.[5] The liquidity of the new issue is generally higher, for example because it is better collateral for repo transactions. Hence, in anticipation of the auction the yield on the previous latest issue is

[4] Often, older bond issues expire on the auction days (which are at regular cycles), so the net supply effect tends to be even smaller.

[5] The switch to the new on-the-run bond does not necessarily occur on the auction day. For instance, Bloomberg, our data source, reports the yield of "*bonds and bills selected on the closest current nominal maturity to the indicated term*". Whereas for Germany the change in the benchmark bond typically happens on the auction day, for Italy it is not standardized and tends to occur a few days after the auction.

expected to increase, because it will go off-the-run and lose liquidity after the auction. Third, the new on-the-run series has a longer maturity than the series that goes off-the-run, implying that, with an upward-sloping term structure, this pushes up the yield on the new on-the-run series compared to the previous on-the-run series.

Finally, most of the bonds in the auctions are bought by a relatively small number of primary dealers. If these primary dealers have limited risk-bearing capacity, for example because they are risk averse or their capital is costly, they need to be compensated for their large position in the asset and the price risk they take on their inventory.[6] This compensation comes in the form of higher auction yields from which the dealers generate trading profits (see Fleming and Rosenberg, 2007). If the dealers' risk aversion or the price risk is larger, one may expect them to charge a higher yield at the auction. Other series, and in particular those for which the returns are highly correlated with the return on the new series, will also see an increase in the yield. Hence, during the run-up to the auction we may expect a rising yield on the latest issue of the same maturity, while after the auction we expect a decrease in the yield of the new (and the old) series as the primary dealers unload their positions in the new issue. For equity markets, empirical evidence in support of the inventory theory has been found by Hansch *et al.* (1998) and Hendershott and Menkveld (2013). These papers detect significant price pressures from dealers' inventories. They also document that inventories are mean reverting with a half-life of one to two-and-a-half days, so that the price pressures are temporary.

2.3. A simple model of primary dealer behavior

We present a simple theoretical framework that models the behaviour of primary dealers with limited risk-bearing capacity. The model is relevant for the primary market, as suggested by the description of the auction processes in the previous subsection. It is also relevant for the secondary market, as the group of secondary-market dealers in public debt to a large extent coincides with the group of primary dealers.

Starting point is the model by Ho and Stoll (1983) of oligopolistic dealers who make the market in several correlated assets. Assuming a mean-variance utility function, in a one-period setting the dealers will quote a price P_j (mid-point of bid and ask prices) based on the

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[6] Simon (1994) explains the underpricing in the auction by the quantity risk involved in bidding at the auction, because the quantity allotted to the bidder may be different from the quantity that the dealer bid for.

equilibrium ("fundamental") value F_j of the asset, corrected for the current inventories of the dealer in all correlated assets (i = 1,..,N; $j \in \{1,..,N\}$):

$$P_j = F_j - A\sum_{i=1}^{N} Cov\left(R_j, R_i\right) I_i,$$

where $Cov\left(R_j, R_i\right)$ is the covariance between the returns on the assets i and j, A is the coefficient of absolute risk aversion and I_i is the inventory in asset i. Hence, the effect of an increase in the inventory of asset i on the price of asset j is given by:

$$\frac{\partial P_j}{\partial I_i} = -ACov\left(R_i, R_j\right) = -A\beta_{ji}\sigma_i^2,$$

where $\sigma_i^2 = Var\left(R_i\right)$ is the variance of the return on asset i and β_{ji} is the exposure of the return on asset j to the return on asset i, $\beta_{ji} = \frac{Cov\left(R_j, R_i\right)}{\sigma_i^2}$. The own price effect of a change in the inventory of asset i simplifies to

$$\frac{\partial P_i}{\partial I_i} = -A\sigma_i^2,$$

and, hence, is proportional to the variance of asset i.

This model yields several useful predictions for our own analysis of the bond auctions. First, an upcoming auction in asset i will lead to a positive inventory position in this asset. This will have a negative effect on the price (and, hence, a positive effect on the yield) at which the asset can be issued. Second, the larger the issuance volume of the auction, the larger the inventory and, hence, the larger this price effect, which is equal to $\left(\partial P_i / \partial I_i\right)\left(\Delta I_i\right) = -A\sigma_i^2 \Delta I_i$. Third, in the run-up to the auction, the yield on the latest issue of the same headline maturity, which we denote by asset j, will increase, as the correlation of returns on bonds with close maturities tends to be high, at least at the daily frequency. Fourth, the price effect on this asset j will be larger if the amount issued of the new asset i of the same headline maturity is larger. This effect equals $\left(\partial P_j / \partial I_i\right)\left(\Delta I_i\right) = -A\beta_{ji}\sigma_i^2 \Delta I_i = \beta_{ji}\left(\partial P_i / \partial I_i\right)\Delta I_i$.

That is, the cross-price effect of an auction in bond *i* on the price of bond *j* is equal to the own price effect on bond *i* multiplied by the return exposure of bond *j* to the return on bond *i*. Therefore, we expect strong effects of the auctions in a particular maturity on the secondary-market price of bonds with a maturity similar to the bond auctioned. Fifth, in a crisis period, the variance of the return on asset *i* is higher and, hence, the effect of an auction of asset *i* of given issuance volume on the prices of assets *i* and *j* will be larger.

3. Auction procedure and data description

Appendix A describes the auctioning procedures for Germany and Italy in detail. Both governments report the days on which public debt auctions take place in an annual issuance calendar, implying that auction dates are precisely known for quite some time in advance. The terms and conditions of each specific auction, including its volume, are announced about a week before it actually takes place.

Acting for the Federal Government, the German Finance Agency (GFA) auctions federal securities via the Bundesbank. Only members of the "Bund Issues Auction Group" can participate directly. Bids above the lowest accepted price are allotted in full. Non-competitive bids are possible and are allotted at the weighted average price of the accepted competitive bids. The auction results are published on the auction day, while the financial settlement and transfer of ownership of the allotted securities typically takes place two days after the auction. Nevertheless, trading in the security on the stock exchange starts immediately after the auction.

The auctioning procedure for Italian public debt, which is done by the Bank of Italy, is similar to the German one, although some specific differences can be identified. Only specific agents, the so-called "Authorized Dealers", can submit bids. The most important difference is that the Italian Treasury uses both competitive and marginal auctions. The former are used for maturities of up to one year and, as in the German case, satisfy bids at the yield offered. Marginal auctions are applied for medium- and long-term securities and have all bidders pay the same price, the so-called marginal price.

Our dataset consists of secondary-market daily yields, KfW-Bund spreads, the ITRAXX Euro 5-year index and information on auctions of 2, 5 and 10-year Treasury bonds for Germany and Italy over the period from 1 January 1999 until 12th February 2013. The secondary-market yields are obtained from Bloomberg, which has agreements with a set of brokers who report their daily bid prices to Bloomberg, which then publishes an average of these prices for their customers. Also the ITRAXX Euro 5-year index is obtained from Bloomberg, while the KfW-Bund spreads, the difference between KfW and German government bond yields, were provided by De Santis (2013), who in turn obtained them from Bloomberg. The information on the auctions is collected both from Bloomberg and directly from the countries' debt agencies. It consists of the specific maturity of the new issue, the auction date, the total amount bid, the total amount allotted and the "average accepted yield" at which the debt is sold.[7]

Over the period since mid-2007 we observe a slight downward trend in the yields on German and Italian debt (see Table 1), although the yields of the latter country exhibit occasionally sharp peaks during this sub-period (not shown). Indeed, the yields have become significantly more volatile since mid-2007. Most of our analysis will distinguish between bond market behavior during the "pre-crisis period" before mid-2007 and the "crisis period" since mid-2007.

Table 2 reports some key statistics for the auctions data. The frequency of the Italian auctions is higher than that for Germany. Moreover, for Italy the frequency of the 2 and 5-year auctions is higher during the first half of the sample, while for Germany for all three maturities the frequency is higher during the recent crisis period. Over the entire sample period, the number of auctions of specific maturities ranges from 90 for 5-year German debt to 189 for 2-year Italian debt. For the sub-periods, these numbers range from 43 for 5-year German debt during the first sub-period to 122 for 2-year Italian debt during the first sub-period. The total number of Italian auctions exceeds the number of German auctions, while Italian auctions are on average smaller, both in terms of the total amounts bid and in terms of the amounts allotted. However, to a large extent the difference in issuance volume is accounted for by Bloomberg not publishing non-competitive bids for Italy (see Footnote 7). As reported by Bloomberg, average total bids in Italian auctions lie in the range of 4 – 5 billion and in German auctions in the range of 6 – 15 billion, while average allotted amounts lie mostly in the range from 1.8 – 3 billion for Italy and in the range of 4 – 6 billion for Germany. The average accepted yields at the auctions for Germany lie uniformly below those for Italy for any given maturity, although the differences are small during the first sub-period.

[7] For Germany, Bloomberg reports the sum of competitive and non-competitive bids, whereas for Italy only competitive bids are published. However, non-competitive supplementary bids are limited to a fixed quotum (fluctuating between 10% and 30%, depending on the type of bond auctioned) of the amount offered. See Appendix A for more details.

These differences are substantially larger during the second sub-period, with the average accepted yield ranging between 1.40 and 2.82 for German debt and between 2.98 and 4.82 for Italian debt. Finally, Table 2 reports average bid-to-cover ratios, which for the full sample period are in the range of 1.7 – 2.2 for Germany and 1.6 – 2.2 for Italy. However, for each of the two countries and for all maturities considered, the average bid-to-cover ratios have gone down. During the first sub-period, the bid-to-cover ratios are in the ranges of 2.0 – 2.6 for Germany and 1.7 – 2.4 for Italy, whereas during the second sub-period the respective ranges are 1.5 – 1.8 for Germany and 1.4 – 1.7 for Italy. Finally, we can see that the average accepted yields are always very close to the secondary-market yields.

4. Event study analysis

This section presents the results of an event study in which we report the average difference between the on-the-run yields during both the 5 trading days before and 5 trading days after the auction and the yield on the auction day.[8] Specifically, following Lou *et al.* (2013) we report the average of $y_t - y_0$, where y_t is the end-of-day yield of the on-the-run Treasury bond on day *t*, and y_0 is the end-of-day yield of the same headline maturity (2, 5 and 10-years) bond on the auction day.[9] We report 90% confidence bands (based on Newey-West adjusted standard errors) around these yield differences. Figure 1a shows these movements in basis points for both countries for the full sample. Consistent with Lou *et al.* (2013) who focus on the U.S. Treasury bond market, we find an inverted-V shaped pattern. That is, there is a tendency for yields to increase in the run-up to the auction and to fall once the auction has taken place. For Italy these movements are both larger and tend to reach a higher degree of significance than for Germany. In the run-up to the auction yields increase by up to 3.5 basis points for five- and ten-year debt and by up to almost 3 basis points for two-year debt. For German debt, the maximum yield increase is around 2.5 basis points for the five-year debt. Next, we split the sample in our two sub-periods. Comparing the before-crisis (Figure 1b) and crisis periods (Figure 1c) we observe that for Germany the differences in the movements of

[8] We limit ourselves to a 10-day window around each auction, because by far most of the movement in the yields is concentrated on these days. Moreover, by focusing on a relatively narrow window we reduce the risk of contamination due to the presence of auctions of different Treasury bonds. These potential effects will be controlled for in the regression analysis below.

[9] As discussed above, Bloomberg reports the yield of the bond or bill with maturity closest to the headline maturity. As a result the underlying benchmark bond may switch within the remaining part of the window after the auction date.

the yields between the two sub-periods are relatively limited when compared with Italy. For Italy yield movements before the crisis are very small and only occasionally significant, while during the crisis they are substantially larger and in many instances highly significant. The magnitude of the movements ranges from around 6 basis points to around 10 basis points at the limits of the window we consider.[10]

A potential complication is that usually in the days before the auction of a maturity *m* debt instrument Bloomberg reports the yields on the latest issue of that maturity, while after the auction Bloomberg switches to reporting the yield on the new issue of maturity *m* debt. In other words, for most auctions we are comparing yield movements in two different instruments (although usually with maturities very close to each other) around the time of the auction. To assess the relevance of this switch of the benchmark bond, for each of the headline maturities we explore the yield movements of an instrument with a maturity close to the headline maturity we consider. Specifically, we study the yields on the 3-year (6-year, 9-year) instrument around the issuance dates of the 2-year (5-year, 10-year) instrument. The advantage of this approach is that we can explore the yields movements on instruments that are kept unchanged as much as possible around the auction dates. Figure 2 shows the results of this variation. Both qualitatively and quantitatively, the results are very similar to those shown in Figure 1. In particular, by far most of the action is for Italy during the second sub-period. These findings suggest that the switch after the auction in the instrument for which yields are reported has no bearing on our results. This casts an interesting perspective on various theoretical explanations for yield movements around auction dates. It suggests that liquidity effects associated with changes in the benchmark security are unimportant. Further, the fact that yield movements during the run-up of auctions tend to be fully reversed after the auction suggests that they are not driven by long-term supply effects. However, our results are fully consistent with the above theory of limited risk-bearing capacity of dealers. According to this theory the price effects of assets with similar risk profiles should be similar.

5. Regression analysis and interpretation of results

The drawback of an event study analysis is the potential presence of confounding factors occurring during the event window. In particular, debt auctions of different maturities

[10] Appendix B reports the numbers for the average yield differences in the window around the auction.

sometimes take place at the same moment or are rather close in time. Moreover, with a regression we can control for other variables, such as auctions in the other sample country.

5.1. Regressions with auction dummies

For maturity *m* of country *i*, we estimate the following equation:

$$\Delta y_t^{i,m} = c_0^{i,m} + \sum_{l=4}^{-5} \beta_l AUC_{t+l}^{i,m} + \sum_{l=4}^{-5} \gamma_l AUC_{t+l}^{i,n(\neq m)} + \sum_{l=4}^{-5} \delta_l AUC_{t+l}^{j(\neq i),m} + \varepsilon_t^{i,m}. \quad (1)$$

where *AUC* is a dummy that takes a value of 1 (0) when there is an (no) auction of the specified country-maturity combination on the indicated date, ε is a disturbance term and $n \neq m$ denotes the maturity of another series. Hence, equation (1) links daily yield changes to upcoming (l>0) or past (l<0) auctions of the same country and same maturity, of the same country and other maturities ($n \neq m$), and of the other country ($j \neq i$) for any maturity. We estimate this equation for Germany and Italy and for the maturities of 2, 5 and 10 years, either setting the γ coefficients to zero or allowing them to be free. We use an *F*-test to test the hypotheses:

$$\begin{aligned} H_0^{\beta}: & \left(\sum_{l=4}^{0} \beta_l\right) - \left(\sum_{l=-1}^{-5} \beta_l\right) = 0, \\ H_0^{\gamma}: & \left(\sum_{l=4}^{0} \gamma_l\right) - \left(\sum_{l=-1}^{-5} \gamma_l\right) = 0, \\ H_0^{\delta}: & \left(\sum_{l=4}^{0} \delta_l\right) - \left(\sum_{l=-1}^{-5} \delta_l\right) = 0. \end{aligned} \quad (2)$$

Similar to the event study of the previous section, we expect that $\sum_{l=4}^{0} \beta_l > 0$ and $\sum_{l=-1}^{-5} \beta_l < 0$. In other words, we test the presence of a full cycle of temporary up and down movements in yields as a result of a given auction.

Table 3 reports the OLS estimates of the coefficient sums $\left(\sum_{l=4}^{0} \beta_l\right) - \left(\sum_{l=-1}^{-5} \beta_l\right)$ and the associated test statistic. The standard errors are Newey-West adjusted. The regression results are in line with the results of the event study. For the full sample period and with only the own maturity included on the right-hand side of the regression equation, we see that for

Germany the cycle of yield movements is significant only for the 5 and 10-year maturity,[11] while for Italy at all maturities the level of significance is higher and the sum of the coefficients is about double the size of that for Germany. Turning to the sub-periods, we see that the action is essentially confined to Italy during the crisis period. In the first sub-period, the only instance of significance concerns the German 10-year auction. In the second sub-period, for Germany only the 5-year maturity is significant, while for Italy all maturities are significant. In addition, the sizes of the Italian coefficient sums are more than double those for the full sample period. For example, for the 2-year maturity the full movement in the yield is 17 basis points over a period of 10 trading days.

Inclusion of another headline maturity of the same country *i* (the γ coefficients) tends to have only limited effect on the size of the own-maturity coefficients when they are significant and does not affect statistical significance at our standard confidence levels. Specifically, the sums of the own-maturity coefficients for Italy during the second sub-period remain highly significant and, in fact, this sum even increases substantially for the 2-year maturity regression with the 10-year alternative maturity. Except in one case, for Italy during the second sub-period the coefficient sums of the alternative maturities are significant or highly significant and substantial in size.

Finally, Table 3 also reports the estimates when the other country *j*'s auction dummy of the same maturity is included in the regression for country *i*, while dropping the dummy for other maturity ($n \neq m$) of country *i* from the right-hand side. The estimated magnitudes of the coefficients on the own dummy of maturity *m* are very similar to the original estimates, while the significance of the coefficients is unchanged in all instances. Hence, for Italy during the second sub-sample, upcoming auctions have a substantial upward effect on the bond yields. The foreign dummy is generally insignificant. Only the yields on the 10-year Italian bond in the full sample and the first sub-sample are affected significantly by auctions of 10-year German debt. In these cases, an upcoming German auction raises yields on same-maturity Italian debt.

5.2. Regressions with issuance volume of the auctions

We can refine baseline regression (1) by replacing the auction dummies with the issuance volume of the auctions:

[11] We term a regression coefficient "significant" when it is statistically significant at the 10% confidence level.

$$\Delta y_t^{i,m} = c_0^{i,m} + \sum_{l=4}^{-5} \beta_l \; VOL_{t+l}^{i,m} + \sum_{l=4}^{-5} \gamma_l \; VOL_{t+l}^{i,n(\neq m)} + \sum_{l=4}^{-5} \delta_l \; VOL_{t+l}^{j(\neq i),m} + \varepsilon_t^{i,m}, \qquad (3)$$

where *VOL* is the total amount allotted, i.e. issuance volume, in billions when there is an auction of the specified country-maturity combination on the indicated date. Otherwise, *VOL* is zero. It is important to recall that the volume of the auction is announced well before the auction, so that any potential feedback effects of yield movements onto the issuance volume of the auction are absent. We expect that, if there is any effect of the auction volume, the effect is positive, because the larger the volume of the auction, the more difficult it will be for the primary dealers to sell their inventory of the acquired new issue. This is borne out by the estimates shown in Table 4. Whenever the coefficient sum is significant, it is positive. The significances of the coefficient sums are very much in line with those for the auction dummies in equation (1). Now, in the case of the full sample regression, for Germany only the 5-year and 10-year regressions yield significance, while for Italy the coefficient sums are highly significant at all maturities and, moreover, the coefficient sums are much larger than in the case of Germany.

Again, most of the action is in the Italian debt in the second sub-period. To give an idea about the magnitude of the effects, for the 2-year maturity an increase by one billion in the amount allotted produces an additional up and down movement in the yield of almost 6 basis points. For the regressions with the other maturity (own country) included, we see that the coefficient sums on the own maturity generally become somewhat smaller, except in the case of the 2-year own maturity combined with the 10-year other maturity, where an additional allotment of one billion produces an almost 10 basis points additional yield. Including the volume of foreign auctions of the same maturity does not affect the estimated size of the coefficients for the own auction.

The estimated yield impacts for Italy in the second sub-period are larger than the estimates for the U.S. auctions documented by Fleming and Rosenberg (2007), who report a 0.3 to 0.5 basis point yield increase per billion dollars auctioned for the five year U.S. Treasury note. The yield impacts can also be compared with the effects of the recent large-scale bond purchases by the ECB. Eser and Schwaab (2013) find a yield decrease for Italy of 1.5 basis points per billion bond purchases.

A relevant question from a policymakers' point of view is whether the movements in the yields around the auction date depend in a nonlinear way on the issuance volume of the auction. For example, if these movements are convex in the auction volume, it may be cheaper for the government to organise more frequent, but smaller auctions. In order to the test the presence of non-linear effects of the auction volume on yield movements, we also estimated regression (3) with (lead and lags of) the squared volume as additional regressors. In the interest of parsimony, we do not report the full results but summarize them. The German auctions reveal only insignificant effects of the volume and its square, except for the case of the 5-year auction during the second sub-period, where the effect of both variables is actually significantly negative. We suspect that this counterintuitive result is caused by the rather low number of observations in this case. Again, in the case of Italy the volume and its square seem to play a larger role. For the 5- and 10-year auctions over the full sample period the coefficient on the volume rises substantially, while the coefficient on the volume-squared is negative and significant for the 10-year auction, suggesting that the effect of the volume on the yield movements is in fact concave. These findings for Italy are substantially strengthened when the sample is confined to the second sub-period.

5.3. The role of the bid-to-cover ratio

Our next variant on the baseline regression aims at investigating the success of the auction on the auction cycle. Success is measured by the bid-to-cover ratio, defined as the total amount bid over the total amount allotted. The resulting regression model becomes:

$$\Delta y_t^{i,m} = c_0^{i,m} + \sum_{l=4}^{-5} \beta_l AUC_{t+l}^{i,m} + \sum_{l=4}^{-5} \gamma_l \left(BC_{t+l}^{i,m} - \overline{BC}^{i,m} \right) AUC_{t+l}^{i,m} + \varepsilon_t^{i,m}. \qquad (5)$$

where BC denotes the bid-to-cover ratio when there is an auction of the specified country-maturity combination on the indicated date. Otherwise, BC is zero. Further, $\overline{BC}$ is the average bid-to-cover ratio over the sample or sub-sample. The terms in the second summation of (5) are only non-zero for auction days. The formulation in (5) ensures that the regressors are theoretically orthogonal to each other, so that the full sample estimates of β in equation (5) are identical to the full sample estimates of β in equation (1). Our hypothesis is that if the auction is more successful than it normally is, i.e. the bid-to-cover ratio exceeds its (sub-)sample average, then the auction cycle will be smaller. Similarly to the previous section we use an *F*-test to test the hypotheses:

$$H_0^{\beta}: \left(\sum_{l=4}^{0}\beta_l\right)-\left(\sum_{l=-1}^{-5}\beta_l\right)=0,$$
$$H_0^{\gamma}: \left(\sum_{l=4}^{0}\gamma_l\right)-\left(\sum_{l=-1}^{-5}\gamma_l\right)=0.$$

Here, H_0^{β} is the null hypothesis that there is no cycle of up and down movements in yields as a result of a given auction, while H_0^{γ} is the null that the degree of success of the auction does not affect the auction cycle.

Table 5 reports the regression results for this variant. The new results show that, for the full sample period, whenever the coefficient sum on the auction dummies is significant, it is positive, while at the same time the coefficient sum on the bid-to-cover ratios tends to be significantly negative. This indicates that, while an upcoming auction leads to a rise in the yield, a larger bid-to-cover ratio reduces the effect on the yield, as a larger relative demand means that the lead parties in the auction can more easily unload their stock of the issue. This pattern is clearly visible for the Italian auctions over the full sample and, in some instances, for the German auctions. The sub-sample split gives less clear results. For both sub-periods the hypothesized pattern of a positive coefficient sum of the auction dummies and a negative coefficient sum of the bid-to-cover ratio is lost for all maturities for Italy, while for Germany it is still there for the first sub-period for 10-year debt and for second sub-period for 5-year debt. The sample split has made the variation in the bid-to-cover ratios too small for Italy to obtain significant effects of the second summation term in (5).

So far we have implicitly assumed that the bid-to-cover ratios are perfectly anticipated before the auction takes place, for example because the participating dealers exchange information on each other's forthcoming bids. However, this seems to be a strong assumption. Therefore, in Table 5 we also report a variant in which only the past values of the bid-to-cover ratios are included, that is we replace $\sum_{l=4}^{-5}\gamma_l BC_{t+l}^{i,m}$ by $\sum_{l=0}^{-5}\gamma_l BC_{t+l}^{i,m}$. Hence, hypothesis H_0^{γ} becomes the hypothesis that $\gamma_0-\left(\sum_{l=-1}^{-5}\gamma_l\right)=0$. For the full sample the results remain qualitatively and quantitatively rather similar, indicating that most of the effect of the auction performance on secondary-market yields occurs in the aftermath of the publication of the auction's bid-to-cover ratios. Also for the sub-samples the results are rather similar, in that there are only few instances in which the coefficient sum of the bid-to-cover terms is significantly negative.

We also estimate a more general equation that allows for the secondary market to react differently according to whether the bid-to-cover ratio is above or below its mean, because it is conceivable that the effect of an unsuccessful auction is stronger the more unsuccessful it is. Concretely, for this case we estimate:

$$\Delta y_t^{i,m} = c_0^{i,m} + \sum_{l=4}^{-5} \beta_l AUC_{t+l}^{i,m} + \begin{bmatrix} \sum_{l=0}^{-5} \gamma_l^G \left(BC_{t+l}^{i,m} - \overline{BC}^{i,m} \right)^G AUC_{t+l}^{i,m} + \\ \sum_{l=0}^{-5} \gamma_l^B \left(BC_{t+l}^{i,m} - \overline{BC}^{i,m} \right)^B AUC_{t+l}^{i,m} \end{bmatrix} + \varepsilon_t^{i,m}, \tag{6}$$

where $\left(BC_{t+l}^{i,m} - \overline{BC}^{i,m} \right)^G$ equals $BC_{t+l}^{i,m} - \overline{BC}^{i,m}$ when this difference is positive (a "good" auction), while it is zero otherwise, and $\left(BC_{t+l}^{i,m} - \overline{BC}^{i,m} \right)^B$ equals $BC_{t+l}^{i,m} - \overline{BC}^{i,m}$ when this difference is negative (a "bad" auction), while it is zero otherwise. *A priori*, we would expect both $\gamma_0^G - \left(\sum_{l=-1}^{-5} \gamma_l^G \right)$ and $\gamma_0^B - \left(\sum_{l=-1}^{-5} \gamma_l^B \right)$ to be negative.

Table 5 also reports the results of the regression in equations (6). In some instances the coefficient sums associated with the auction dummies lose statistical significance, although in all instances they are rather close to significance. The full-sample results for Italy indeed suggest the presence of a non-linearity, in that a fall in a relatively low bid-to-cover ratio strengthens the auction cycle, while this is not the case for a fall in a relatively high bid-to-cover ratio. We do not report subsample results, as the variation in the bid-to-cover ratios becomes too small to obtain significant estimates.

6. Probing further into the effects of crises

A comparison of the results for Germany and Italy and for Italy over the two sub-sample periods suggests that in a situation of crisis auctions cause larger yield movements. We split the full sample at around the time when the global economic and financial crisis started with the problems in the U.S. housing market. This split still leaves us with a number of auctions in each sub-period that is sufficient for our regression analysis. However, the second sub-period is characterised by periods of smaller and larger tensions in the financial markets (e.g., see Beetsma, Giuliodori, de Jong and Widijanto, 2013). In particular, the European debt crisis erupted in full in the fall of 2009 after the discovery that the Greek deficit for that year would end up much higher than originally foreseen. While first Greece, Ireland and Portugal had to be put under rescue programs, later the debt crisis spread to Italy and Spain. After the announcement of the ECB President around mid-2012 that the ECB would do whatever it takes to safeguard the euro, European sovereign debt markets seem to have calmed down. Hence, in this section we re-estimate our baseline regression for periods of our second sub-sample that were characterised by a relatively high degree of tension, while we will also link the yield movements around auctions to indicators of tensions in the European sovereign debt market.

Table 6 reports the estimates for the most basic version of equation (1) with all γ_l and δ_l equal to zero. The first regression repeats for convenience the results for the entire second sub-sample. The second regression focuses on the period since September 2009, the period that starts just before the start of the Greek crisis. We see that the results for Italy remain highly significant and become quantitatively stronger. The third and fourth regressions split the second sub-sample into the period before September 2010 when the debt crisis had not yet spread to Italy and the period as of September 2010 when the debt crisis started spreading also to Italy. While for the period before September 2010 the auction effects are significant to highly significant, the period as of September 2010 is characterised by quantitatively much larger effects. The final regression excludes from this last sub-period the period since August 2012, i.e. since the statement of the ECB President. The period September 1st 2010 – July 31st 2012 is characterised by the quantitatively largest effects of auctions on yield movements, in line with the fact that tensions in the market for Italian public debt were at their strongest.[12]

The preceding evidence suggests that the auction effects are larger during periods of a high degree of intensity of the crisis. Therefore, our second approach is to relate the yield movements around auctions directly to the degree of crisis intensity during the period since July 2, 2007. To this end, we estimate regression equations of the format:

$$CYCLE_t^{i,m} = \beta_0 + \beta_1 CRINT_t + \varepsilon_t^{i,m}, \quad (7)$$

where $CYCLE_t^{i,m}$ is size of the full auction cycle, that is the sum of the run-up ($y_t^{i,m} - y_{t-5}^{i,m}$) and the run-down ($y_t^{i,m} - y_{t+5}^{i,m}$) phases, and $CRINT_t$ is a variable that stands for the average "degree

[12] Notice, though, that the shrinking number of observations undermines the significance of the estimates.

of crisis intensity" during the 10-day window around the auction date *t*. Ideally we would use some measure of the volatility of European sovereign debt markets to measure the crisis intensity. However, while such an index exists for the European stock market, we are not aware of the existence of such an index for the European sovereign debt market. Hence, as proxies of crisis intensity we use instead the KfW-Bund spread for the 10-year maturity (KFW) and the ITRAXX Euro 5-year index (ITRAXX). The former measures liquidity pricing effects and is a direct measure of stress in the European bond market, while ITRAXX captures credit risk. Both variables are expressed in basis points. They are depicted in Figure 4. Interestingly, there seems to be a break around mid-2007, the start of our crisis period, when both variables started to pick up strongly and fluctuate far more heavily than before. We also see that the two variables are strongly correlated – the correlation coefficient is 0.89. Table 7 reports the estimates of β_1 in equation (7). In all instances β_1 is estimated positively for Italy. The ITRAXX is significant for 2- and 5-year Italian debt, while the KfW Bund spread is significant for the 5-year Italian debt. A 100-basis points increase in the ITRAXX produces a 42 basis points increase in the combined up and down movement of the yield on 5-year Italian debt around auctions. For German auctions the effects of our crisis intensity measures are always insignificant and substantially smaller in magnitude than for Italy. Overall, the additional results presented in this section suggest that a more intense crisis leads to larger secondary-market movements in the yields of vulnerable countries around the moment that they issue new debt.

7. Applications

7.1 Assessing the potential debt issuance costs

In the spirit of Lou *et al.* (2013) the observed yield movements surrounding auctions can be exploited to provide an estimate of the issuance costs borne by the government. Obviously, the problem in calculating these issuance costs is that the secondary-market instrument from which we estimate the yield movements generally differs from the instrument that is auctioned in the primary market. In particular, except in the case of a reopening of an existing bond, the auctioned instrument is newly created and becomes the new on-the-run benchmark instrument for its headline maturity shortly after the auction.

In view of the preceding discussion, and to estimate issuance costs on the basis of the movements in secondary-market yields, it is necessary to secure that there is a strong relationship between primary- and secondary-market yields. To establish this relationship, we estimate for each country *i* and maturity *m* combination the regression

$$y_{A,t}^{i,m} = \alpha_0 + \alpha_1 y_{b,t}^{i,m} + v_t, \tag{8}$$

where *t* runs over auction days only, $y_{A,t}^{i,m}$ is the average accepted yield on the country *i* and maturity *m* debt instrument on auction day *t* and $y_{b,t}^{i,m}$ is the corresponding secondary-market yield at the beginning of auction day *t*. We include the beginning rather than the closing yield on the auction date, because the former is in the information set of the primary dealers when the auction takes place. To allow for the possibility of a break, the constant and the slope of equation (8) are allowed to differ between the first and second sub-periods. The (unreported) estimates show that there is an almost perfect one-to-one relationship between the average accepted yield on the auctioned instrument and the secondary-market yield at the start of the auction day. That is, in all instances α_1 is (very close to) one. These findings suggest that the movements in the issuance cost as captured by the average accepted yield can be approximated to a high degree of precision by the movements of the yields in the secondary market.

Hence, we calculate the issuance cost by using the movements in the secondary-market yield during the run-up to the auction. We run the regression:

$$\Delta y_{b,t}^{i,m} = c_0^{i,m} + \sum\nolimits_{l=L}^{0} \beta_l AUC_{t+l}^{i,m} + \varepsilon_t^{i,m}, \tag{9}$$

and take the estimate of the coefficient sum $\sum\nolimits_{l=L}^{0} \beta_l$ to assess the effect of the run-up of the auction on the debt yield.

Table 8 reports the estimates of $\sum\nolimits_{l=L}^{0} \beta_l$ for L=4. Clearly, for Italy the yield movements as a result of the run-up to an auction are larger than for Germany. We focus on Italy to provide a rough calculation of the issuance costs based on the full-sample data. For example, using Tables 2 and 8 the average issuance cost that we calculate for an auction of 5-year Italian debt is an additional annual interest payment of 2,519 million (the average amount allotted) times 3.12 basis points, which is approximately 785,000 euro's per year. To obtain the cost for the full length of the issue we need to multiply this number by the duration of a typical 5-year bond. The duration can be calculated as a function of the length of the period between settlement date and maturity date, the coupon rate, the frequency of coupon payments and the average accepted yield at the auction date. We randomly take three five-year bonds issued in 2006, which have an average duration of 4.36 years, and three random five-year bonds issued in 2012. These have an average duration of 4.52 years. For the full sample we use an average duration of (4.36+4.52) = 4.44 years. Hence, we calculate a total issuance cost of 785,000 times 4.44 is 3.5 million euros. Assuming that all the currently outstanding debt issued by the Italian Treasury has been subject to the same issuance cost of approximately 3 basis points, the additional *annual* cost to the Treasury is almost 500 million euros (1,640 billion euros times 3 basis points).

The larger estimated effects of the auction dummies going from the first to the second sub-period suggest that issuance costs have increased for Italy as a result of the economic and financial crisis. It is of interest to report an estimate of this *increase* in the issuance cost between the two sub-periods so as to gauge the effects of a crisis on the issuance costs. We do this calculation as an average for the entire second sub-period, being aware that the crisis intensity was at times much higher than on average. Using Tables 2 and 8 for the average amounts allotted and the run-up effect of the auction, we find for the first sub-period an estimate of the issuance cost of 2,183 million times 0.35 basis points times an average duration of 4.36, which is roughly 330,000 euros. The corresponding number for the second sub-period is 3,080 million times 7.53 basis points times 4.52, which is roughly 10.5 million. Hence, going from the pre-crisis to the crisis period the increase in the average issuance cost for 5-year Italian debt is around 10 million euros. Going from the pre-crisis to the crisis period a complete roll-over of the entire stock of debt would raise the annual costs associated with the issuance by 1,640 billion euros times (7.53-0.35) basis points, which is about 1.2 billion euros. Of course, it is important to realise that all these are only rough and indicative estimates of the issuance costs.[13]

7.2 Do yield movements around auctions constitute excess profit opportunities?

[13] In particular, on average the accepted yield has risen rather substantially relative to the secondary-market yield when going from the first to the second sub-period, suggesting that the increase in the issuance cost between the two periods is a rather generous lower bound to the true increase in the issuance cost.

Market participants could sell the on-the-run bond or a close-maturity off-the-run bond prior to the auction, when the price is still relatively high, and buy it back on the day of the auction, when the price has fallen, and in this way try to make a profit. However, whether this constitutes an opportunity to make excess profits is a question that for at least two reasons cannot be easily answered.

First, an investor has to overcome the transactions costs involved in this trading strategy. These costs are mainly the bid-ask spread. When selling the security, the trader loses the difference between the "fundamental price" and the bid price, while when buying the security, the trader loses the difference between the ask price and fundamental price. Hence, a rough estimate of the transaction cost of the proposed trading strategy is the full bid-ask spread for the average trading day. Pelizzon *et al.* (2013, their Table 6) report an estimate of the quoted bid-ask spread of Italian 5-year debt of 0.378% of the price of the debt.[14] Bid-ask spreads potentially differ during and around auction days from other days, but we do not have the data to check this. Hence, we use the numbers derived in Pelizzon *et al.* (2013). Dividing the above number for the bid-ask spread by a roughly-estimated duration of 4.44 years translates into a 8.5 basis points spread relative to the annual yield on the debt. The corresponding effective bid-ask spread is 2.7 basis points.

Second, the strategy is not riskless and it may well be the case that the uncertainty about the returns also increases around auction days. Table 9 reports the standard deviations of daily yield differences during the five days in the run-up to the auction and days outside the 10-day auction window. The standard deviations of the yield differences in a majority of the cases are higher during the run-up to the auction. However, the differences are generally not too large in magnitude, although they are statistically significant in many cases. We can assess the possibility of making an "excess profit" by calculating the Sharpe ratio (*SR*) for the abovementioned trading strategy as:

$$SR = \frac{5\mu - ba}{\sqrt{5}\sigma},$$

where μ is daily return (the yield difference) during the run-up to the auction, σ the standard deviation of the daily return and *ba* the bid-ask spread, all expressed in yield basis points.

[14] Assuming that the trader is a price taker, hence, cannot "time" the market to get a good bid-ask spread, it makes sense to use the quoted rather than the effective bid-ask spread as the basis for our calculations.

Using the quoted bid-ask spread and the numbers in Tables 11 and 13, we find for the run-up period *SR* = (7.53-8.5) / (√5*12.10) = -0.036. Using the effective bid-ask spread, we find that *SR* = (7.53-2.7) / (√5*12.10) = 0.18. Notice that this is the Sharpe ratio for one auction. As there are auctions typically once a month, this strategy can be repeated twelve times per year. Assuming a risk-free investment in the non-auction periods, the annual Sharpe ratio for the strategy then is √12*0.18 = 0.62 if one uses the effective spread as the transaction cost measure, and √12*-0.036 = -0.12 if the transaction costs are equal to the quoted spread. These numbers are smaller than the annualized Sharpe ratio of the similar strategy reported for U.S. Treasury auctions by Lou *et al.* (2013). They find a Sharpe ratio above 1 before transaction cost and 0.95 after transaction costs. The explanation for the difference is the following: before transaction costs, our Sharpe ratios are similar, but the transaction costs on Italian bonds in the recent period are much higher than the transaction costs for US treasury bonds. Lou *et al.* (2013) report transaction costs of 2.44% of the price of a 10-year bond. This translates into 0.3 basis points bid-ask spread on the yield, compared to a 2.7 basis points effective spread and a 8.5 basis points quoted spread for the Italian bonds. Hence, even with the (relatively low) effective spread estimates of transaction costs, our after-cost Sharpe ratios are smaller than those found in Lou *et al.* (2013) and more in line with Sharpe ratios of other risky investment strategies.[15] When traders have to pay the quoted spread, the after-cost trading profits are negative.

8. Concluding remarks

We have explored the relationship between public debt auctions and secondary-market yields and how this relationship is affected by the recent crisis. While secondary-market yields on Italian public debt increase in anticipation of an auction, no or a smaller such effect is found for German public debt. The yield movements on Italian debt are essentially confined to the period starting mid-2007. Together, these results suggest a significant role for the crisis in determining this relationship. Moreover, they are consistent with our simple theoretical framework in which a small group of primary dealers require compensation for inventory risk and this compensation needs to be higher when market uncertainty is larger. We also find that the secondary-market behaviour of debt for which there is *no* auction, but with a maturity

[15] For example, a typical stock index investment with 3% excess return and 15% volatility has an annual Sharpe ratio of 0.20. Lou *et al.* (2013) report Sharpe ratios for momentum strategies in the order of 0.60.

close to that of the auctioned series, is very similar to the secondary-market behaviour of the auctioned maturity. This finding supports a model of primary dealers with limited risk-bearing capacity relative to other explanations based on liquidity effects.

Our results also allow us to make a rough assessment of the increase in the public debt issuance costs as a result of the crisis. For example, for a five-year bond issue this increase is estimated at around 10 million euro's over its entire life. However, this figure is likely a lower bound on the effects that a really deep crisis may have. Finally, although secondary-market yields move appreciably around auctions, these movements seem insufficient to develop profitable trading strategies that overcome their associated transactions costs and the increase in market volatility during the run-up of an auction. Even so, there may be timing opportunities for parties that for exogenous reasons are forced to trade.

Finally, we argue that the design of the auction mechanism may matter. Italy and Germany use slightly different auction mechanisms, where Italy always sells the full amount but Germany sometimes withholds some bonds of demand is low. If the issuer can mitigate quantity or price risk in the auction, the auction cycle can possible be mitigated too. We argue that this difference in auction design may be an element in explaining why the auction cycle for Germany is almost absent, whereas it is strong and very sensitive to the crisis for Italy.

References

d'Amico, S. and T. King, 2013, Flow and Stock Effects of Large-Scale Treasury Purchases: Evidence on the Importance of Local Supply, *Journal of Financial Economics*, forthcoming.

Beetsma, R., Giuliodori, M., de Jong, F. and D. Widijanto, 2013, Spread the News: the Impact of News on the European Sovereign Bond Markets during the Crisis, *Journal of International Money and Finance* 34, 83-101.

De Santis, R.A. (2013), The Euro Area Sovereign Debt Crisis: Flight to Liquidity, Credit Rating Agencies and the Spread of the Fever from Greece, Ireland and Portugal, earlier version published as *ECB Working Paper*, No. 1419.

Eser, F. and B. Schwaab, 2013, Assessing Asset Purchases within the ECB's Securities Markets Programme, *ECB Working Paper*, No. 1587.

Fleming, M.J., and E.M. Remolona, 1997, What Moves the Bond Market? *Federal Reserve Bank of New York Economic Policy Review* (December), 31–50.

Fleming, M.J. and J.V. Rosenberg, 2007, How Do Treasury Dealers Manage their Positions? *Federal Reserve Bank of New York Staff Reports*, No. 299.

Forest II, J.J., 2007, The Effect of Treasury Auction Results on Interest Rates: 1990-1999, *Mimeo*, University of Massachusetts, Amherst.

Goldreich, D., 2007, Underpricing in Discriminatory and Uniform-Price Treasury Auctions, *Journal of Financial and Quantitative Analysis*, 443-466.

Hansch, O., Naik, N. and S. Viswanathan (1998), Do Inventories Matter in Dealership Markets? Evidence from the London Stock Exchange, *Journal of Finance* 53, 1623-1656.

Hendershott, T,. and A. Menkveld (2013), Price Pressures, *Mimeo*, University of California at Berkeley.

Ho, T.S.Y. and H.R. Stoll, 1983, The Dynamics of Dealer Markets under Competition, *Journal of Finance* 38, 4, 1053-1074.

Joyce, M., Lasaosa, A., Stevens, I. and M. Tong, 2011, The Financial Market Impact of Quantitative Easing in the United Kingdom, *International Journal of Central Banking* 7, 3, 113-161.

Krishnamurthy, A. and A. Vissing-Jorgensen, 2011, The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy, *Brookings Papers on Economic Activity*, Fall.

Krishnamurthy, A. and A. Vissing-Jorgensen, 2012, The Aggregate Demand for Treasury Debt, *Journal of Political Economy* 120, 2, 233-67.

Lou, D., Yan, H. and J. Zhang, 2013, Anticipated and Repeated Shocks in Liquid Markets, *Mimeo*, London School of Economics and Yale University, available on SSRN.

Nyborg, K.G. and S. Sundaresan, 1996, Discriminatory versus Uniform Treasury Auctions: Evidence from When-Issued Transactions, *Journal of Financial Economics* 42, 63-104.

Pelizzon, L., Subrahmanyam, M.G., Tomio, D. and J. Uno, 2013, The Microstructure of the European Sovereign Bond Market: A Study of the Euro-zone Crisis", *Mimeo*, New York University.

Simon, D.P., 1994, Markups, Quantity risk, and Bidding Strategies at Treasury Coupon Auctions, *Journal of Financial Economics* 35, 43-62.

Table 1: Means and standard deviations of daily yield changes

	Germany			Italy		
	2-year	5-year	10-year	2-year	5-year	10-year
Mean (in basis points)						
Before crisis	0.06	0.05	0.03	0.06	0.06	0.04
Crisis	-0.29	-0.26	-0.20	-0.19	-0.09	-0.02
Equality test	0.02	0.06	0.13	0.36	0.55	0.76
Standard deviation (in basis points)						
Before crisis	4.09	4.37	3.85	4.10	4.36	3.90
Crisis	5.31	5.77	5.35	12.28	10.44	8.02
Equality test	0.00	0.00	0.00	0.00	0.00	0.00

Notes: This table reports the means and standard deviations of the 2, 5 and 10 year government bond yield of Germany and Italy. Data cover the period January 1, 1999 – February 12, 2013. "Before crisis" refers to the period January 1, 1999 – June 30, 2007, while "Crisis" refers to the period July 1, 2007 – February 12, 2013. The "Equality test" reports the *p*-value of the *F*-test of equality of means, respectively variances.

Table 2: Summary statistics for the auctions

	Germany			Italy		
	2-year	5-year	10-year	2-year	5-year	10-year
	Full sample period					
Number of auctions	114	90	104	189	168	166
Av. amount bid (mil.)	11,663	9,145	9,378	4,296	4,221	4,276
Av. amount allotted (mil.)	6,465	5,856	6,462	2,167	2,519	2,729
Av. bid-to-cover ratio	1.817	1.568	1.451	2.151	1.767	1.612
Av. accepted yield (%)	2.27	2.82	3.55	3.24	3.99	4.67
	January 1, 1999 – June 30, 2007					
Number of auctions	55	43	52	122	105	95
Av. amount bid (mil.)	14,747	11,461	12,164	4,100	4,096	4,326
Av. amount allotted (mil.)	6,927	6,535	7,500	1,826	2,183	2,489
Av. bid-to-cover ratio	2.188	1.772	1.674	2.403	1.949	1.767
Av. accepted yield (%)	3.20	3.74	4.31	3.38	4.03	4.55
	July 1, 2007 – February 12, 2013					
Number of auctions	59	47	52	67	63	71
Av. amount bid (mil.)	8,751	7,026	6,591	4,655	4,428	4,210
Av. amount allotted (mil.)	6,034	5,234	5,423	2,788	3,080	3,049
Av. bid-to-cover ratio	1.472	1.382	1.228	1.692	1.465	1.405
Av. accepted yield (%)	1.40	1.97	2.80	2.98	3.94	4.82

Notes: This table reports summary statistics on the auctions of the 2, 5 and 10 year government bond yield of Germany and Italy. Data cover the period January 1, 1999 – February 12, 2013. In the table, "Av." = "average", "mil." = "million". In the case of Germany the average amount allotted refers to the issuance volume. The latter includes also the amount retained by the Federal Government for secondary market operations. For consistency with the Italian case, the German bid-to-cover ratio is calculated as ratio between the total bid volume and total issuance volume.

Table 3: Estimates of auction effects on yields

	Germany			Italy		
	2-year	5-year	10-year	2-year	5-year	10-year
	Full sample period					
Dummy own	2.11	3.34*	3.39***	5.64***	6.80***	6.12***
Dummy own		3.08*	2.99**		6.03***	5.66***
Dummy 2-year		-1.92	-1.87		4.34**	1.88
Dummy own	2.27		3.67***	4.97**		5.80***
Dummy 5-year	1.91		1.60	4.59**		3.63***
Dummy own	1.86	3.44*		3.92*	6.10***	
Dummy 10-year	-0.90	0.49		3.78	6.04***	
Dummy own	2.21	3.07*	3.39**	5.61***	7.00***	6.23***
Dummy foreign	0.96	1.00	0.95	-4.21	-5.55	4.14**
	January 1, 1999 – June 30, 2007					
Dummy own	2.27	-0.31	4.61***	-0.64	1.50	0.93
Dummy own		-0.29	4.55***		1.77	1.60
Dummy 2-year		0.15	-0.45		0.56	-0.34
Dummy own	2.42		4.48***	-0.39		1.21
Dummy 5-year	0.12		-0.71	1.19		1.33
Dummy own	2.31	-0.077		-0.93	1.75	
Dummy 10-year	0.44	1.56		0.39	0.60	
Dummy own	2.28	-0.67	4.43***	-0.67	1.52	0.90
Dummy foreign	-0.44	1.57	0.19	0.74	-0.81	3.57**
	July 1, 2007 – February 12, 2013					
Dummy own	1.95	6.75***	2.15	16.93***	15.48***	13.01***
Dummy own		6.44**	0.95		13.68***	11.11
Dummy 2-year		-3.40	-3.62		11.98***	15.42**
Dummy own	2.44		3.04	15.81***		11.66***
Dummy 5-year	4.13*		3.87*	10.99**		6.77**
Dummy own	1.11	6.79***		28.65***	12.57***	
Dummy 10-year	-2.70	-0.22		1.60	12.78***	
Dummy own	2.33	6.43***	2.21	16.12***	15.17***	13.27***
Dummy foreign	2.90	0.58	1.83	-7.44	-8.96	4.34

Notes: (i) This table reports estimates of equation (1), $\Delta y_t^{i,m} = c_0^{i,m} + \sum_{l=4}^{-5} \beta_l AUC_{t+l}^{i,m} + \sum_{l=4}^{-5} \gamma_l AUC_{t+l}^{i,n(\neq m)} + \sum_{l=4}^{-5} \delta_l AUC_{t+l}^{j(\neq i),m} + \varepsilon_t^{i,m}$, where *AUC* is the dummy for the day of the auction. The table reports, in basis points, the estimated sums of the coefficients $-\sum_{l=-1}^{-5} \beta_l + \sum_{l=4}^{0} \beta_l$ for "Dummy own" (the maturity-country combination in the header); $-\sum_{l=-1}^{-5} \gamma_l + \sum_{l=4}^{0} \gamma_l$ for "Dummy 2-year", "Dummy 5-year" and "Dummy 10-year"; and $-\sum_{l=-1}^{-5} \delta_l + \sum_{l=4}^{0} \delta_l$ for "Dummy foreign". (ii) Significance at the 10, 5 and 1% level is denoted by *, ** and ***, respectively. (iii) Estimation method is ordinary least squares (OLS) with Newey-West adjusted standard errors. (iv) "Dummy foreign" is the same-maturity Italian (German) dummy corresponding to Dummy own" for Germany (Italy).

Table 4: Estimates of issuance volume effects on yields

	Germany			Italy		
	2-year	5-year	10-year	2-year	5-year	10-year
	Full sample period					
Volume own	0.30	0.52	0.60***	3.17***	2.56***	2.04***
Volume own Volume 2-year		0.48 -0.31	0.55*** -0.28		2.11*** 2.40***	1.16* 2.20***
Volume own Volume 5-year	0.33 0.29		0.62*** 0.21	2.98*** 1.67**		1.91*** 1.49***
Volume own Volume 10-year	0.28 -0.09	0.54* 0.16		3.49*** -0.41	2.32*** 2.11***	
Volume own Volume foreign	0.31 0.68	0.48 0.48	0.59*** 0.21	3.23*** -0.45	2.62*** -0.80	2.08*** 0.61***
	January 1, 1999 – June 30, 2007					
Volume own	0.28	-0.16	0.64***	-0.018	0.78	0.32
Volume own Volume 2-year		-0.16 -0.03	0.64*** -0.07		0.83 0.50	0.34 0.35
Volume own Volume 5-year	0.29 -0.08		0.62*** -0.21	0.21 0.55		0.40 0.70
Volume own Volume 10-year	0.28 0.03	-0.13 0.22		0.028 -0.38	0.85 0.12	
Volume own Volume foreign	0.28 0.11	-0.21 0.94*	0.62*** 0.09	0.05 0.10	0.80 -0.23	0.32 0.49**
	July 1, 2007 – February 12, 2013					
Volume own	0.34	1.50***	0.50	5.74***	4.11***	3.54***
Volume own Volume 2-year		1.43*** -0.56	0.31 -0.58		3.29*** 3.93***	1.81 6.69***
Volume own Volume 5-year	0.45 0.94**		0.68* 0.89**	5.25*** 2.68*		3.22*** 2.06**
Volume own Volume 10-year	0.24 -0.36	1.58*** 0.14		10.49*** -2.96	3.43*** 3.83***	
Volume own Volume foreign	0.38 0.99	1.44*** 0.17	0.49 0.28	5.58*** -0.99	4.05*** -1.58	3.64*** 0.69

Notes: This table reports estimates of equation (3), $\Delta y_t^{i,m} = c_0^{i,m} + \sum_{l=4}^{-5} \beta_l \ VOL_{t+l}^{i,m} + \sum_{l=4}^{-5} \gamma_l \ VOL_{t+l}^{i,n(\neq m)} + \sum_{l=4}^{-5} \delta_l \ VOL_{t+l}^{j(\neq i),m} + \varepsilon_t^{i,m}$, where *VOL* denotes the volume of the auction. "Volume own" corresponds to the maturity-country combination in the header, while "Volume foreign" is Volume of the same-maturity Italian (German) auction in the case of the regression for Germany (Italy). The coefficient sums are now in basis points per billion euros. Further, the Notes to Table 3 apply.

Table 5: Estimates of auction effects on yields with the bid-to-cover ratio

	Germany			Italy		
	2-year	5-year	10-year	2-year	5-year	10-year
	Full sample period					
Dummy own	2.11	3.34*	3.39**	5.64***	6.80***	6.12***
Dummy own	2.11	3.34*	3.39**	5.64***	6.80***	6.12***
BC own	-1.09	-0.99	-5.34**	-6.68***	-6.34*	-7.42*
Dummy own	2.11	3.34*	3.25**	5.64***	6.80***	6.12***
BC own past	-2.17	-3.83	-6.86***	-3.93**	-6.26**	-5.60
Dummy own	3.24*	4.81*	2.59	3.33	3.46	2.94*
BC own past good	-3.36**	-6.62	-5.89***	-1.46	-0.16	1.17
BC own past bad	1.16	1.11	-9.38	-10.12	-18.55*	-24.95**
	January 1, 1999 – June 30, 2007					
Dummy own	2.27	-0.31	4.61***	-0.64	1.50	0.93
Dummy own	2.27	-0.31	4.30***	-0.64	1.52	0.93
BC own	-1.19	10.29*	-8.33***	-0.81	-1.85	2.77
Dummy own	2.27	-0.31	4.38***	-0.64	1.51	0.93
BC own past	-1.53	2.52	-6.78***	-0.21	-0.96	1.25
	July 1, 2007 – February 12, 2013					
Dummy own	1.95	6.75***	2.15	16.93***	15.48***	13.01***
Dummy own	1.95	6.75***	2.17	16.98***	15.46***	13.03***
BC own	-3.23	-15.64**	-1.87	-9.02	32.05*	-8.58
Dummy own	1.95	6.75***	2.15	16.98***	15.46***	13.02***
BC own past	-4.13	-8.30	-8.59	-2.65	9.36	-6.02

Notes: (i) This table reports estimates of equation (5),

$\Delta y_t^{i,m} = c_0^{i,m} + \sum_{l=4}^{-5} \beta_l AUC_{t+l}^{i,m} + \sum_{l=4}^{-5} \gamma_l \left(BC_{t+l}^{i,m} - \overline{BC}^{i,m} \right) AUC_{t+l}^{i,m} + \varepsilon_t^{i,m}$, where *AUC* denotes the dummy for the day of the auction and *BC* denotes the bid-to-cover ratio, and equation (6)

$$\Delta y_t^{i,m} = c_0^{i,m} + \sum_{l=4}^{-5} \beta_l AUC_{t+l}^{i,m} + \begin{bmatrix} \sum_{l=0}^{-5} \gamma_l^G \left(BC_{t+l}^{i,m} - \overline{BC}^{i,m} \right)^G AUC_{t+l}^{i,m} + \\ \sum_{l=0}^{-5} \gamma_l^B \left(BC_{t+l}^{i,m} - \overline{BC}^{i,m} \right)^B AUC_{t+l}^{i,m} \end{bmatrix} + \varepsilon_t^{i,m}.$$

The table reports, in basis points, the estimated sum of the coefficients $-\sum_{l=-1}^{-5} \beta_l + \sum_{l=4}^{0} \beta_l$ for "Dummy own", i.e. the auction dummy for the maturity-country combination in the header, and $-\sum_{l=-1}^{-5} \gamma_l + \sum_{l=4}^{0} \gamma_l$ for "BC own", i.e. the bid-to-cover ratio for the maturity-country combination in the header. (ii) For "BC own past", $\sum_{l=4}^{-5} \gamma_l BC_{t+l}^{i,m}$ is replaced by $\sum_{l=0}^{-5} \gamma_l BC_{t+l}^{i,m}$ and the table reports the estimate of $\gamma_0 - \sum_{l=-1}^{-5} \gamma_l$. (iii) For "BC own past good" and "BC own past bad" the table reports the estimates of, respectively, $\gamma_0^G - \sum_{l=-1}^{-5} \gamma_l^G$ and $\gamma_0^B - \sum_{l=-1}^{-5} \gamma_l^B$ (regression equation (6)). (iv) Further, see Notes to Table 3.

Table 6: Estimates of auction effects on yields during sub-samples of the crisis period

	Germany			Italy		
	2-year	5-year	10-year	2-year	5-year	10-year
	July 1, 2007 – February 12, 2013					
Dummy own	1.95	6.75***	2.15	16.93***	15.48***	13.01***
	September 1, 2009 – February 12, 2013					
Dummy own	1.50	3.63	-0.88	22.49***	17.25**	14.36***
	July 1, 2007 – August 31, 2010					
Dummy own	2.98	11.76***	7.13**	7.94**	6.41*	8.19***
	September 1, 2010 – February 12, 2013					
Dummy own	0.89	2.59	-2.50	27.84**	26.09***	18.55***
	September 1, 2010 – August 1, 2012					
Dummy own	0.27	3.73	-3.18	29.03**	26.22**	19.91***

Notes: (i) This table reports for various sub-periods estimates of equation (1), $\Delta y_t^{i,m} = c_0^{i,m} + \sum_{l=4}^{-5} \beta_l AUC_{t+l}^{i,m} + \sum_{l=4}^{-5} \gamma_l AUC_{t+l}^{i,n(\neq m)} + \sum_{l=4}^{-5} \delta_l AUC_{t+l}^{j(\neq i),m} + \varepsilon_t^{i,m}$, where *AUC* is the dummy for the day of the auction. The table reports, in basis points, the estimated sums of the coefficients $-\sum_{l=-1}^{-5} \beta_l + \sum_{l=4}^{0} \beta_l$ for "Dummy own" (the maturity-country combination in the header); $-\sum_{l=-1}^{-5} \gamma_l + \sum_{l=4}^{0} \gamma_l$ for "Dummy 2-year", "Dummy 5-year" and "Dummy 10-year"; and $-\sum_{l=-1}^{-5} \delta_l + \sum_{l=4}^{0} \delta_l$ for "Dummy foreign". (ii) Significance at the 10, 5 and 1% level is denoted by *, ** and ***, respectively. (iii) Estimation method is ordinary least squares (OLS) with Newey-West adjusted standard errors. (iv) "Dummy foreign" is the same-maturity Italian (German) dummy corresponding to Dummy own" for Germany (Italy).

Table 7: Estimates the impact of crisis intensity on the auction cycle

	Germany			Italy		
	2-year	5-year	10-year	2-year	5-year	10-year
	KfW					
β_1	0.117	-0.029	0.038	0.230	0.853***	0.154
	ITRAXX					
β_1	0.046	-0.062	-0.016	0.383*	0.420***	0.201

Notes: The table reports the OLS estimates of equation (7), $CYCLE_t^{i,m} = \beta_0 + \beta_1 CRINT_t + \varepsilon_t^{i,m}$, where *CYCLE* is the magnitude of the auction cycle and *CRINT* denotes either the KfW-Bund spread or the ITRAXX credit risk index. Variables are expressed in basis points. Significance (based on Newey-West adjusted standard errors) at the 10, 5 and 1% level is denoted by *, ** and ***, respectively.

Table 8: Estimates of run-up effect five days before the auction

Germany			Italy		
2-year	5-year	10-year	2-year	5-year	10-year
Full sample period					
1.67	3.10**	1.45	2.61	3.12*	4.09***
January 1, 1999 – June 30, 2007					
1.83	1.56	2.31*	-0.29	0.35	1.91*
July 1, 2007 – February 12, 2013					
2.06	5.12**	0.82	7.38*	7.53**	7.17***

Notes: We report estimates of $\sum_{l=4}^{0}\beta_l$ in equation (9), $\Delta y_{b,t}^{i,m} = c_0^{i,m} + \sum_{l=4}^{0}\beta_l AUC_{t+l}^{i,m} + \varepsilon_t^{i,m}$, where *AUC* denotes the dummy for the day of the auction. See also the Notes to Table 3.

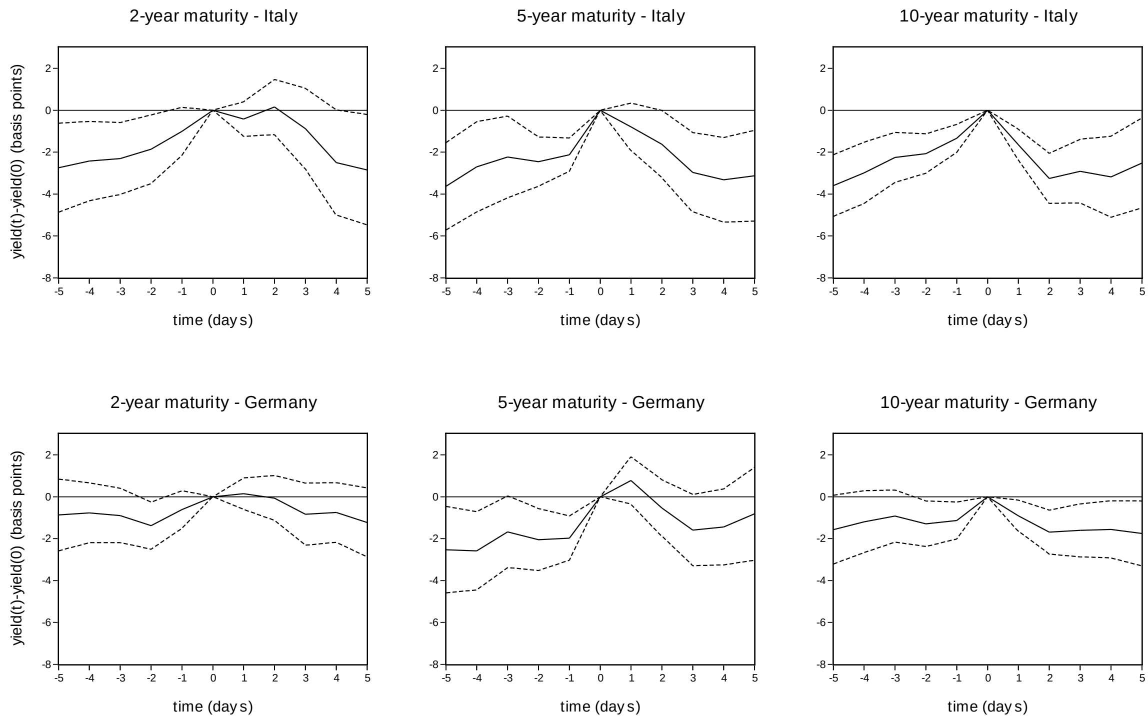
Table 9: Mean and volatility of daily yield change in run-up to auctions versus other days

	Germany			Italy		
	2-year	5-year	10-year	2-year	5-year	10-year
	Full sample period					
Mean – normal	-0.09	-0.15	-0.07	-0.08	-0.04	-0.06
Mean – run-up	0.17	0.51	0.28	0.55	0.73	0.72
S.D. – normal	4.56	4.88	4.44	8.91	6.97	5.87
S.D. – run-up	4.89	5.37	4.77	7.81	8.26	5.10
	January 1, 1999 – June 30, 2007					
Mean – normal	0.09	-0.05	-0.02	0.01	-0.13	-0.06
Mean – run-up	0.21	0.45	0.62	0.03	0.44	0.27
S.D. – normal	4.10	4.33	3.87	3.90	4.25	3.86
S.D. – run-up	4.23	4.34	3.90	4.18	4.55	3.72
	July 1, 2007 – February 12, 2013					
Mean – normal	-0.45	-0.34	-0.16	-0.20	0.10	-0.05
Mean – run-up	0.14	0.56	-0.06	1.49	1.21	1.32
S.D. – normal	5.32	5.72	5.35	12.66	9.58	8.20
S.D. – run-up	5.44	6.17	5.50	11.80	12.10	6.46

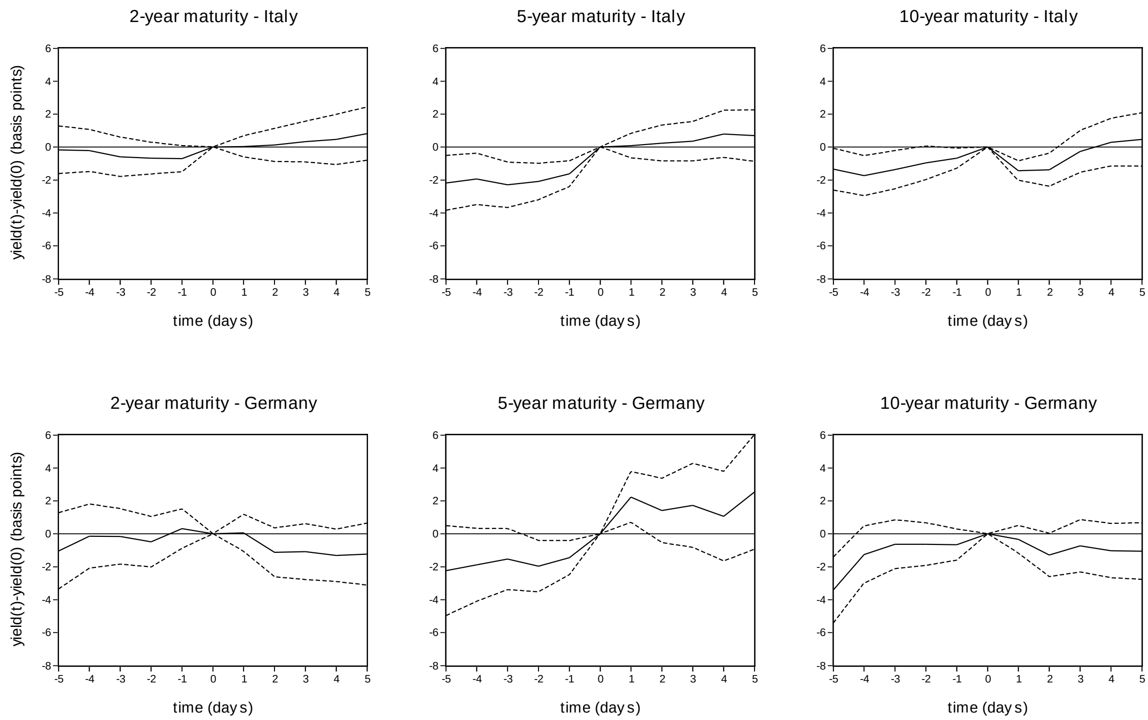
Notes: Numbers are in basis points. The "run-up" is the 5-day window before and including the auction day. "S.D." is the standard deviation of the day-to-day change in the bond yield. "Normal" is the period excluding the full auction cycle (i.e., the run-up and run-down phases of the cycle).

Figure 1: Yield movements before and after auctions

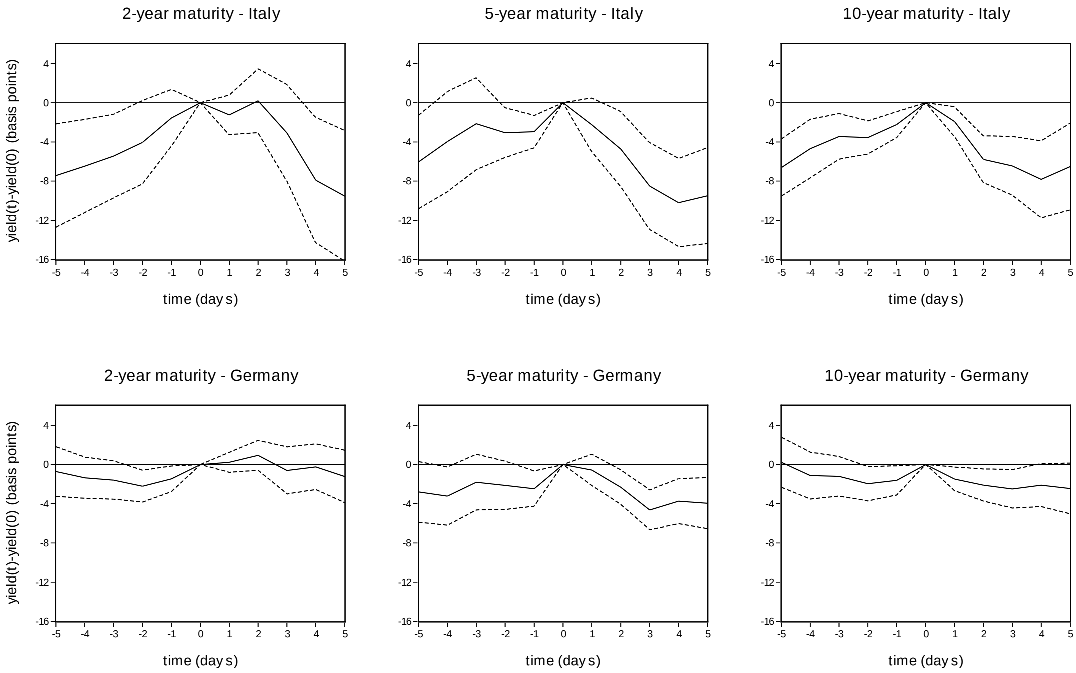
a. Full sample



b. Sub-period January 1, 1999 – June 20, 2007



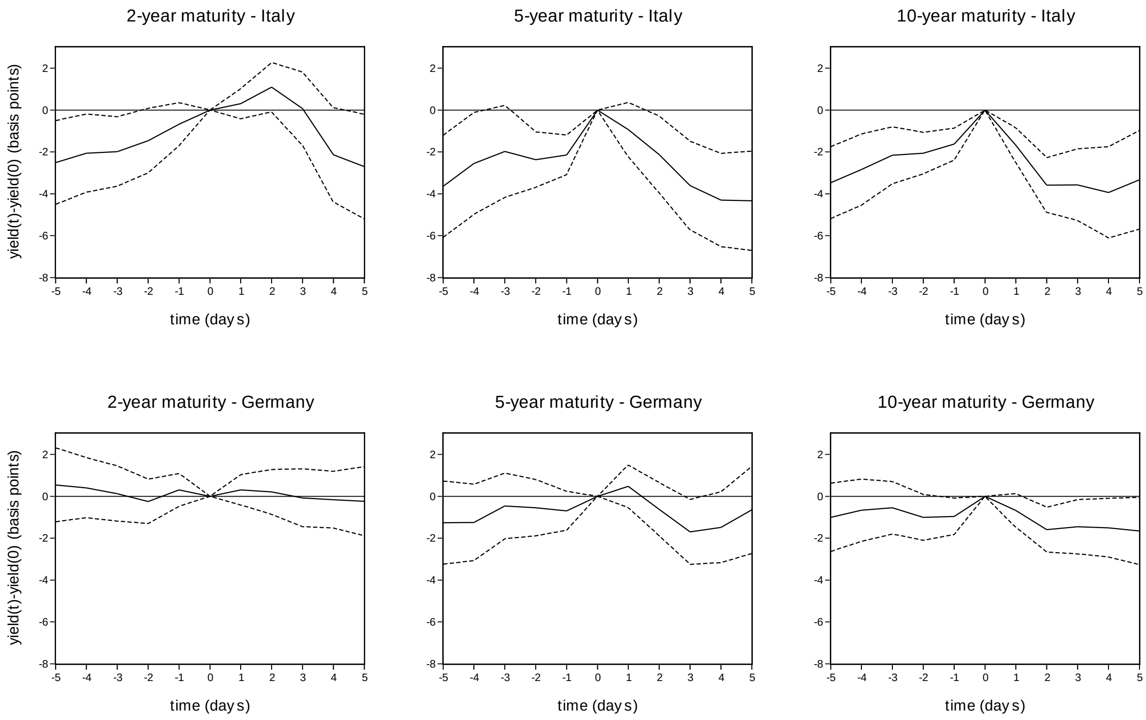
c. Subperiod July 1, 2007 – February 12, 2013



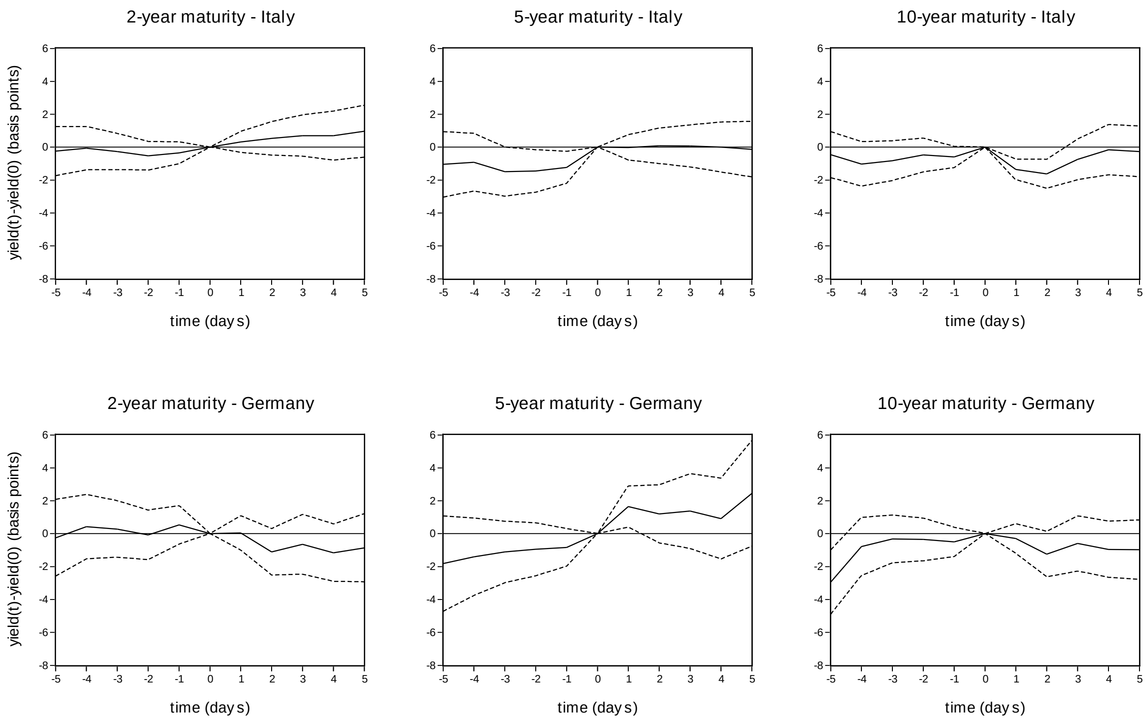
Notes: The figure reports the average of $y_t - y_0$, where y_t is the yield of the Treasury bond on day *t*, and y_0 is the yield on the same maturity bond on the auction day 0. All yields are expressed in basis points. The dotted lines are the 90% confidence intervals with Newly-West adjusted standard errors.

Figure 2: Yield movements around auctions – close maturities

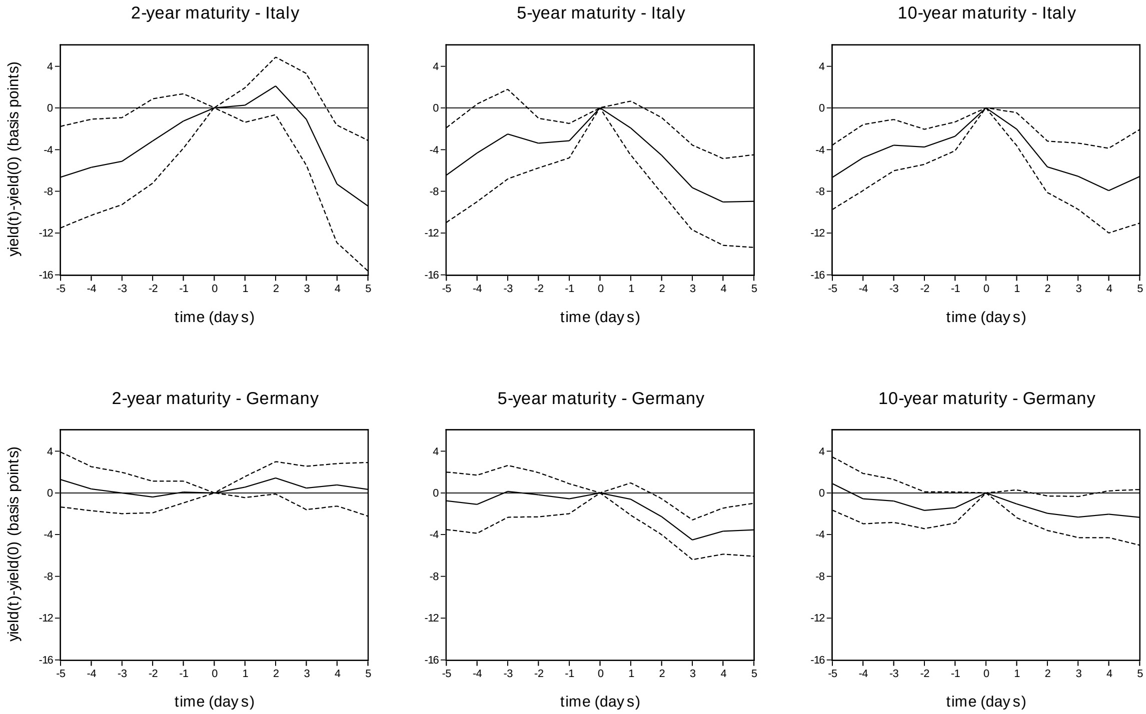
a. Full sample



b. Sub-period January 1, 1999 – June 30, 2007



c. Sub-period July 1, 2007 – February 12, 2013



Notes: the figure reports the average yield movements of the 3-year bond around auctions of 2-year debt, of the 6-year bond around auctions of the 5-year debt and the 9-year bond around auctions of the 10-year debt. Further, see the *Notes* to Figure 1.

Appendix A: Background information on auction procedures

A.1. Germany

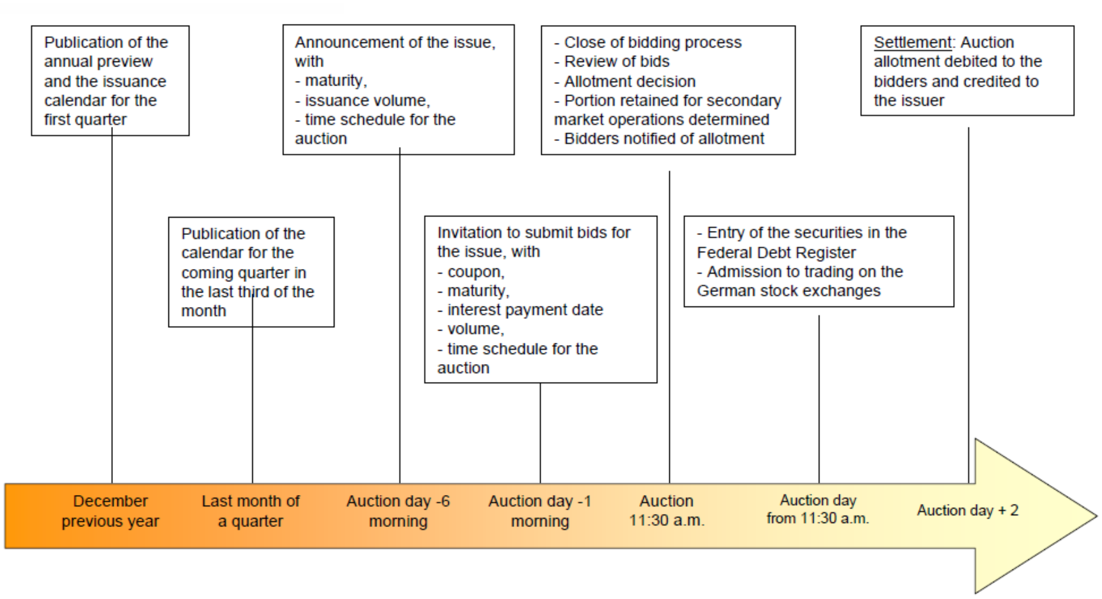
The Deutsche Bundesbank, on behalf of the German Finance Agency (GFA), acts as the fiscal agent of the Federal Government and fulfills the specific tasks related to the issuance and settlement of federal securities. The Bundesbank carries out the auctions of Treasury discount paper (6 and 12-month maturity "Bubills"), Federal Treasury notes (2-year maturity "Schätze"), five-year Federal notes ("Bobls") and Federal bonds (10 and 30-year maturity "Bunds").[16] Only members of the "Auction Group Bund Issues" can participate directly in these auctions. During 2012, the Auction Group comprised 37 credit institutions selected by the GFA. The Group included both German banks (for example, Deutsche Bank and Commerzbank) and foreign banks (for example, Goldman Sachs International Bank, Société Générale, UniCredit Bank, ABN-AMRO).

The procedure to place the individual issues in a year *t* is standardized as follows – see Figure A.1. Towards the end of the preceding year the annual preview and the issuance calendar are published. Further, towards the end of the month preceding a new quarter the new calendar for the coming quarter is published. Then, six days before each auction there is an announcement of the maturity, the issuance volume and time schedule of the auction, while a press release inviting the members of the Auction Group to submit their bids is sent out one working day before the auction. The auctions take place between 8.00 a.m. and 11.30 a.m. and bids are operated through the Bund Bidding System (BBS), an electronic primary-market platform. The bidders are bound by their bid until the allotment has taken place at the price

[16] The Bundesbank also executes the auctions of inflation-linked Federal notes (five-year Bobl/ei) and inflation-linked Federal bonds (10-year Bund/ei). Other financial instruments of the Federal Government include foreign currency bonds, special securitized loans ("Schuldscheindarlehen") and bonds issued in cooperation with the German Federal States.

specified in their bids. As a result, bids are not settled at a uniform price. Bids above the lowest accepted price are allotted in full. Non-competitive bids are also possible and are filled at the weighted average price of the competitive bids accepted. Importantly, the Federal Government reserves the right to reject all bids, to scale down bids quoting the lowest accepted price, and/or to scale down non-competitive bids. This implies that at the auctions the Federal Government may retain a certain amount of the instrument for secondary market operations after the auction.[17] The auction results are published on the auction day, while the financial settlement and ownership transfer of the allotted securities take place two days after the auction, although the security is admitted to trading on the German stock exchange immediately after the auction.

Figure A.1: German Auction Procedure



Source: http://www.deutsche-finanzagentur.de/en/institutional/primary-market/auction-procedure/.

[17] The volume retained for secondary market operations varies widely from auction to auction, but since 2005 it has averaged around 20% of the primary issuance volume.

A.2. Italy

In Italy, the Ministry of Economy and Finance issues, on the domestic market, four main categories of government bonds: Treasury bills ("BOTs" with a 3, 6, and 12-month maturity or with a flexible maturity between 1 and 12 months), zero-coupon Treasury bonds (24-month maturity "CTZs"), Treasury certificates (5 or 7-year maturity "CCTs"/"CCTs-eu" with a semi-annual floating coupon) and Treasury bonds (3, 5, 10, 15 and 30-year maturity "BTPs").[18] The auctions are executed by the Bank of Italy and their procedure is similar to that for Germany, although specific differences can be identified. Towards the end of each year, the Ministry of Economy and Finance publishes the auctions calendar for the following year. This is followed by the publication of a quarterly issuance programme. The terms and conditions of an auction are published roughly one week before the auction. The "Authorized Dealers" who are allowed to participate in the auction are Italian, EU and non-EU banks, financial brokers and EU and non-EU investment companies registered at the Bank of Italy.[19] After subscribing to the auction, where the deadline is the day before the auction, dealers can send their bids electronically through the National Interbank Network strictly before 11.00 a.m. of the auction day.

The most important feature of the auction procedure is that the Treasury uses both competitive and marginal auctions. Competitive auctions are used for maturities of up to one year, and, as in the German case, bids are satisfied at the individual yield offered.[20] Marginal

[18] The Ministry also issues Treasury bonds linked to the euro-zone inflation (3, 5, 10, 15 and 30-year maturity "BTPs €i") and to the Italian inflation ("BTPs Italia"). Other instruments typically offered on international markets include medium/long-term securities or commercial paper in euros and in other currencies.

[19] A fixed share (between 10% and 35%, depending on the type of bond) of the amount offered in each auction is reserved for "Specialists", who are dealers selected (and evaluated year-by-year) by the Ministry of Economy and Finance. The specialists are allowed to participate in the non-competitive supplementary re-openings which occur on the following working day after each auction. For Italy, Bloomberg does not publish the bids of and amounts offered to the specialists. Hence, this information is not included in our auction dataset.

[20] Before April 2009 bids were satisfied at the price offered. Each dealer can submit a maximum of three bids. In order for the accepted yields to be in line with the market yields, a minimum acceptable yield, also called the safeguard yield, is calculated. Similarly, a maximum acceptable yield, or the exclusion yield, is calculated to avoid speculative behavior. An example of the calculation of these yields can be found in

(or uniform-price) auctions are applied for medium- and long-term securities, with all bidders paying the same price, the so-called marginal price. The dealers participating in the auction of medium and long-term bonds are awarded a commission in the range of 0.20% to 0.40% of the amount allotted in order to compensate them for having collected bids from the public. For medium and long-term bonds the settlement takes place two working days after the auction.

http://www.dt.tesoro.it/export/sites/sitodt/modules/documenti_en/debito_pubblico/titoli_di_stato/Government_bond_Auctions.pdf.

Appendix B: Average yield movements in window around auction

Table B.1 – Estimated yield movements in window around auction

	Full sample period					
	Germany			Italy		
t	2-year	5-year	10-year	2-year	5-year	10-year
-5	-0.87	-2.53**	-1.57	-2.74**	-3.64***	-3.60***
-4	-0.77	-2.59**	-1.19	-2.43**	-2.71**	-3.00***
-3	-0.90	-1.67	-0.92	-2.31**	-2.23*	-2.25***
-2	-1.38**	-2.05**	-1.30**	-1.87*	-2.45***	-2.07***
-1	-0.61	-1.98***	-1.14**	-1.01	-2.12***	-1.34***
1	0.14	0.78	-0.90**	-0.42	-0.79	-1.64***
2	-0.06	-0.53	-1.70***	0.15	-1.62*	-3.26***
3	-0.83	-1.60	-1.61**	-0.88	-2.97**	-2.91***
4	-0.76	-1.44	-1.56*	-2.50	-3.33***	-3.18***
5	-1.23	-0.81	-1.75*	-2.85*	-3.13**	-2.52**

	January 1, 1999 – June 30, 2007					
	Germany			Italy		
t	2-year	5-year	10-year	2-year	5-year	10-year
-5	-1.04	-2.23	-3.41***	-0.18	-2.18**	-1.34*
-4	-0.14	-1.88	-1.26	-0.22	-1.94**	-1.73**
-3	-0.16	-1.53	-0.63	-0.59	-2.29***	-1.37*
-2	-0.48	-1.96**	-0.63	-0.67	-2.09***	-0.96
-1	0.31	-1.45**	-0.66	-0.71	-1.62***	-0.68*
1	0.06	2.24**	-0.33	0.03	0.08	-1.43***
2	-1.13	1.41	-1.29	0.13	0.24	-1.38**
3	-1.08	1.73	-0.73	0.33	0.36	-0.27
4	-1.31	1.07	-1.02	0.46	0.80	0.30
5	-1.23	2.54	-1.05	0.82	0.69	0.46

	July 1, 2007 – February 12, 2013					
	Germany			Italy		
t	2-year	5-year	10-year	2-year	5-year	10-year
-5	-0.72	-2.80	0.23	-7.43**	-6.04**	-6.62***
-4	-1.36	-3.23*	-1.13	-6.46**	-3.97	-4.68**
-3	-1.59	-1.80	-1.22	-5.44**	-2.14	-3.44**
-2	-2.22**	-2.13	-1.97*	-4.04	-3.05*	-3.56***
-1	-1.47*	-2.46**	-1.62*	-1.55	-2.95***	-2.23***
1	0.22	-0.56	-1.48**	-1.25	-2.25	-1.93**
2	0.93	-2.32**	-2.10**	0.20	-4.73**	-5.77***
3	-0.60	-4.64***	-2.49**	-3.07	-8.51***	-6.45***
4	-0.23	-3.74**	-2.10	-7.90**	-10.20***	-7.83***
5	-1.23	-3.95**	-2.46	-9.53**	-9.49***	-6.50**

Notes: (i) This table reports the average of $y_t - y_0$, where y_t is the yield of the bond at the end of day *t*, and y_0 is the yield on the same bond at the end of the auction day 0. (ii) All numbers are in basis points. (iii) Standard errors are Newey-West adjusted. (iv) Significance at the 10, 5 and 1% levels is denoted by *, ** and ***, respectively.