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Fuel up with OATmeals! The case of the French nominal yield curve☆

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Abstract

We construct the French nominal yield curve using Svensson[33] methodology and all available public data of French nominal government debt securities—*Obligations Assimilables du Trésor* (OATs). Our sample period starts in October 1987 and ends in April 2018. We find that the functioning of the French sovereign bond market has improved dramatically following the onset of the euro area and has been functioning reasonably well since then, with the exceptions of the Global Financial Crisis period and the European sovereign crisis period. We also find that, the French nominal on-the-run securities have, on average, a negligible liquidity premium, in sharp contrast to the U.S. nominal Treasury market, where such a premium is sizable. On average, the level and the slope of the French zero-coupon rates have been decreasing since the Global Financial Crisis.

JEL classification: G12; G13; G14

Keywords: French nominal government bonds; Term structure of French interest rates; OATs; Yield curve; Svensson model; On-the-run premium; Sovereign spread; Predictability

1. Introduction

As in a number of OECD countries, the French sovereign bond debt market was constantly growing over the past few decades. As of April 2018, the total outstanding amount of the French government negotiable debt securities was

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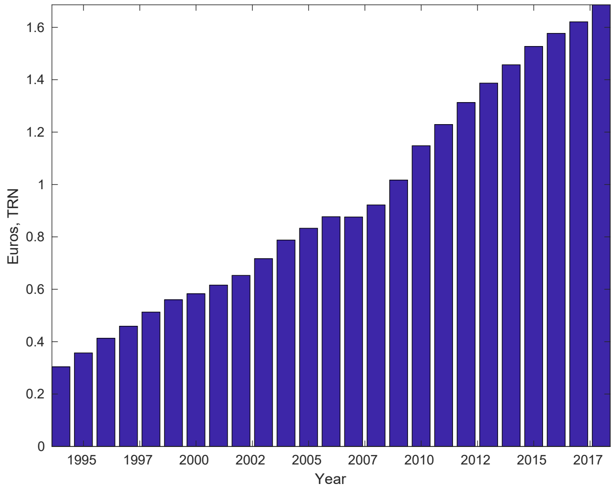

Fig. 1. Notional Amount of the French Nominal Debt. This figure shows the outstanding notional amount of the French nominal government debt (BTF, BTANs, and OATs) from December 1993 to December 2017. Data are hand-collected and merged from the monthly newsletters released by the Agence France Trésor.

€ 1725 billion, 92 percent of which was represented by medium- and long-term debt securities.[1] Fig. 1 plots the year-end notional outstanding amount of the French short-, medium-, and long-term securities since 1993.[2] The market has grown almost six-fold, from about € 300 million in 1993 to about € 1700 million in 2018. According to the summary of world-wide debt securities published by the Bank of International Settlements, as of September 2019, the French nominal sovereign bond market has been the second largest sovereign debt market in Europe: The total outstanding amount of the UK debt market is 2831 billion of US dollars, that of the French debt market — 2263 billion of U.S. dollars, followed by the German debt market whose outstanding notional debt amount is 1743 billion of US dollars.[3]

According to, Batten et al[5] the French public bond market is known to be very liquid: *"The market is also very highly regarded worldwide as a benchmark reference because of the regularly held auctions and fungibility, it is already the second most liquid in the world after its American equivalent."* Despite its size, the French public debt market and variability of the associated interest rates are not well studied in the academic literature. Because the interest rate is considered to be one of the basic components in both financial economics and macroeconomics, the availability of the historical French yield curve should be an incredibly useful tool for researchers in these areas. In this paper, we construct the historical French yield curve, provide some facts, and answer questions related to French interest rates.

To our knowledge, we are the first to comprehensively study more than 30 years of all available public data of French government securities prices. To that end, we have constructed the nominal yield curves at a daily frequency during this sample period, thus making it possible to study the evolution of French interest rates in detail.

In particular, we fully implement the Gürkaynak et al[21] GSW from now on empirical methodology on all available and eligible French nominal bond securities. We rely on the yield curve fitting methodology of Svensson[33]; since our

[1] Source: https://www.aft.gouv.fr/files/archives/attachments/26686.pdf. For general discussions on the budget and the financing policies of the French state, one may consult monthly newsletters published by the *Agence France Trésor* (AFT) and working papers provided by Banque de France on its website. Established in February 2001, the AFT is an important institution whose goal is to manage the French government treasury (including a day-to-day perspective), define for the government the debt strategy, control and manage the risk and provide back office services, provide macroeconomic and financial analysis and expertise, collect and diffuse economic information, and cooperate with international sister organizations. It has been engaged for years in a strategy to refinance the total debt and to benefit from the favorable low financing conditions. Many statistical figures and general comments we present hereafter are based on the October 2017 technical notes of the ECB[11] and also BFS. See also a recently published report by the OECD.[30]

[2] We did not find outstanding notional amounts for earlier dates, as the first publicly available AFT newsletter was issued in January 1998; the end of 1993 is the earliest outstanding amount reported there. Note also that, in order to plot this graph, we convert into euros the notional amounts of bonds that were issued in French francs or ECUs prior to the onset of the euro area. The conversion rate of ECU to euros is 1:1.

[3] Source: https://stats.bis.org/statx/srs/table/c1?f=pdf.

goal is to obtain some reliable estimates of intermediate/long-horizon yields that would potentially provide useful information about (variation of) macroeconomic fundamentals in France.[4] We document a number of interesting facts about the French government bond market and French interest rates.

Our first result is related to the recurrent and open question about the existence of the so-called on-the-run premium on government debt markets. This phenomenon refers to the fact that investors are willing to pay a (liquidity) premium for the newly issued government obligations, which, therefore, trade at higher prices relative to the previous most recent issues of the debt. Based on two different empirical strategies, we find no evidence of the on-the-run premium on the French market. Statistically, we find that the French on-the-run premium has been, on average, negligible and within the bounds determined by the model mean absolute fitting errors. This is clearly a distinct feature compared with the U.S. nominal Treasury securities market, where various researchers document a sizable on-the-run premium (see ref.[21,36,25,14,17,31]). Potential factors that explain the absence of such a premium is (1) a debt issuance process in France that differs from the United States, (2) a very active and regulated repo market in France, (3) tax treatment of OATs, and (4) an active OAT futures market.[5] Our result complements early empirical evidence of Ejsing and Sihvonen [12]; who find that on-the-run premium does not exist in the German sovereign bond market. In France, similarly to many other European countries and in contrast to the United States, the government debt reopenings are common and easy because the government bonds are fungible in these countries.[6]

Our second result shows the dynamics of the French nominal yield curve. Fitted zero-coupon yields indicate a clear downward trend in interest rates since the Global Financial Crisis (GFC), consistent with declining interest rates in other countries, particularly the United States. Toward the end of our sample, interest rates in France appeared to have reached a zero-lower-bound level. In addition, the slope of the term structure as measured by, for example, the difference in the 10- and 2-year yields has been declining as well. Numerous studies (such as Ang, Piazzesi, and Wei[3] find that the changes in slope predict the changes in the GDP growth, so our findings may be useful to macroeconomists, central bankers, and policy makers.

Our third result is related to the functioning of the French sovereign bond market that has considerably improved since the onset of the euro area, which we relate to the influx of outside investors to the French market. In fact, according to the noise measure of Hu et al [22] HPW from now on that reflects the (un)availability of arbitrage capital on a market, our findings suggest that the French market development can be decisively separated into pre-euro (1988−1998) and euro (1999−2018) periods in our sample.

The rest of the paper is organized as follows. Section 2 describes some institutional details of the French government bond market. Section 3 describes our data set. Section 4 describes the methodology behind the Svensson curve estimation. Section 5 reports the results and investigates the shape and the dynamics of the fitted zero-coupon yield curve. Section 6 focuses on the on-the-run premium issue of the French government bond market. Section 8 explores the period preceding the euro's 1999 launch. Section 9 concludes.

2. The French government bond market

The French treasury (FT hereafter) has a long history of bond issuances and security innovations as different marketable debt securities have been issued by the French government for years. *Bons du Trésor à Taux Fixe et à Intérêt Précompté* (BTFs), *Bons du Trésor à Taux Fixe et à Intérêts Annuels* (BTANs) and *Obligations Assimilables du Trésor* (OATs) roughly correspond to short-, medium-, and long-term securities, respectively. These acronyms are similar, for example, to Treasury bills, Treasury notes, and Treasury bonds in the United States, and Bubills, Schaetze/Bobls, and Bunds in Germany. BTFs are standard bills issued on a discount basis and redeemed at par. Their maturity is expressed in weeks, and the most frequently maturities are 13, 26, and 52 weeks. Hence, their initial maturity is equal to or less than one year. In principle, these bonds are issued to manage short-term operations. Both BTANs and OATs are, in general, coupon bonds although there exist some zero-coupon bonds, too. BTANs, first issued on February 11, 1986, were debt securities with initial maturities between 2 and 5 years. However, as of January 1, 2013, the FT stopped issuing BTANs

4 Starting with Ricart and Sicsic[32]; the Svensson approach is used by the Banque de France, when it passes the test against the Nelson-Siegel curve fitting model.

5 We have conducted informal interviews and discussions with market participants in the French government bond market and bond portfolio managers in insurance companies who confirmed that these are potential channels for explaining the absence of the on-the-run premium.

6 In the United States, government debt is mostly issued in the form of the new issue, which corresponds to the on-the-run security.

and started issuing only two types of sovereign securities, BTFs and OATs. The last BTAN debt was fully reimbursed on July 25, 2017, and the total BTAN debt amounted to € 1188 billion during its period of existence. The goal of stopping the issuance of BTANs under their original name was to simplify the structure of the issued French public debt. Since then, medium-term securities have been renamed as OATs. Currently, all existing OATs and BTFs are euro-denominated French debt securities. Most of the marketable government debt has a residual maturity of more than one year, and the current average duration, as of April 2018 equals 7 years and 288 days.[7]

The term "assimilable" in OATs refers to the fact that these securities are fungible with identical characteristics: the same expiration date, the same coupon rate and the same face value.[8] This also means that newly issued bonds blend in with the bond debt issue that contains these vintage bonds. At first sight, this may appear very similar to the U.S. reopening device. However, they are not exactly the same. First, in France, bond debt management relies explicitly on an initial *souche*, which is the very first debt issue that will serve as a matrix for the following ones. The newly issued bonds are so fungible that vintage bond and newborn bonds are effectively indistinguishable, and it is not really appropriate to talk about a new tranche. Second, two mechanisms differ with respect to the usage policy. In France, it is a general way to respond to the demand. In the United States, reopenings are used to manage the short debt squeezes (see ref.[34]). Third, they differ in terms of issuance features. In the United States, both standard auctions and "tap" issues are used by the Treasury for reopening purposes. In France, new bonds that contribute to an existing souche are offered by auction (*adjudication*).

A limited portion of the French public bond debt (€ 200 million) is adjusted to inflation according to two indexes: the French CPI index (*l'indice des prix à la consommation en France*) and the HICP euro index (*l'indice des prix de la zone Euro*). The first inflation-adjusted French government bond, *Obligations Assimilables du Trésor indexée sur l'indice des prix à la consommation en France (OATi)*, was issued on September 15, 1998. In October 2001, the French government issued the first for *Obligations Assimilables du Trésor indexée sur l'indice des prix de la zone Euro (OAT€i)*. At last, some bond debts have been denominated in other currencies (USD and GBP), but they represent at most less than 3 percent of the total outstanding amount. These specific segments of the French government bond market are out of the scope of the present research, because they deserve tailored investigations. We do not consider currently these bonds in our dataset for the purposes of this paper.

The French OATs/BTANs bond market experienced a number of different periods since its onset in 1984. During the first period, the bond market was regularly exposed to some political events and institutional changes. From a macroeconomic perspective, the French franc-denominated debt was exposed to the French political risk factor during a number of economic episodes. From a microeconomic perspective, the market increased gradually in credibility and liquidity. As an example of these changes, the *Marché à Terme International de France* (MATIF) that was opened in 1986, proposed a number of interest rate derivatives. Later, the OATs bond stripping was authorized in 1991, which allowed people to make arbitrage between zero-coupon and coupon bonds and one may also refer to floating-rate OATs, called OAT TEC 10 that were first issued in April 9, 1996 and to the regular improvement of the legal and market environment for repos transactions (including the technique of "pension livrée" in 1988, the designation of 20 market makers in 1994 from merging *Spécialistes en Valeurs du Trésor (SVTs)* and *Spécialistes en Pensions sur Valeurs du Trésor (SPVTs)*, and the use of the ISMA Master Agreement for repos since the euro launch). The *Agence de la Dette* then renamed *Agence France Trésor* (AFT) was created on February 8, 2001. All these innovations contributed to a well functioning and liquid French bond market, which is highly attractive for investors.

[7] The full list of a given debt can be found in the monthly newsletter of the AFT: https://www.aft.gouv.fr/files/archives/attachments/26686.pdf. More information on characteristics of OAT securities can be found here: https://www.aft.gouv.fr/fr/presentation-oat.

[8] Two exceptions to this general principle are worth discussing. The first one arises when the newly issued bonds are restricted to certain investors as individuals (that is, *particuliers*). The second one comes from the inclusion, as of January 1, 2013, of some collective action clauses in the debt contract. Now, like all bonds issued in the euro area after January 1, 2013, OATs have some collective action clauses. As a result, they are not entierly fungible with bonds issued prior to this date.

The investor clientele on the French bond market has profoundly changed over the 35 years of the market's existence. In the 1980s, large investors were mainly French institutional investors sometimes called *zinzins*[9] as well as some large state-owned companies. By law, *zinzins* are required to be engaged in some long-term strategies such as the buy-and-holds of OAT securities. For their part, insurance companies are concerned by asset-liability management issues. In the 1980s, no one had incentive to actively trade these bonds or even to lend them on the repo market. With the onset of the euro area, these political and institutional issues became less significant as new outside investors came into the market. In fact, nonresident holdings of French government negotiable debt securities regularly increased from about 15 percent of the total negotiable debt outstanding in early 1998 (about one year before the euro) to almost 30 percent at the end of 2000. Nonresident participation in the market reached its peak of 71 percent in June 2010.[10]

3. Data

We identify the list of all French government marketable debt securities available on Bloomberg by their ISIN number. We then select all BTANs and OATs with fixed coupons.[11] Each ISIN number refers to a specific and original issuance of bonds. OATs debt is fungible, similarly to many other European bonds. The very first issue with some given characteristics is called *souche*. *Souches* are uniquely identified by the ISIN number. In the course of the *souche* life, an additional debt amount can be added to the existing *souche*. This additional debt amount would have the same characteristics as the primary bond and, in particular, would have a maturity that would be equal to the remaining maturity of the primary *souche*, that is to have the same maturity date. Newly issued bonds are fungible with existing ones meaning that there are no separate ISINs/CUSIPs for these issues and thus it is impossible to identify them separately.

Before the launch of the euro, the fixed-coupon bonds that we collected were denominated in FF (French francs) at issuance, and, in a very few cases, in XEU (or ECU, European Currency Unit). The OATs started to be denominated in euros on January 1, 1999, following the onset of the euro area. All OATs pay annual fixed coupons and have neither special nor optional features.[12]

Ultimately, our data set consists of daily available bid prices for 179 nominal OATs from October 22, 1987, through April 10, 2018. Thus, our data set contains 315,877 individual daily price quotes. For each of the 179 OATs in our sample, Tables A1–A5 in Appendix A provide the security type (as it can be an OAT or a BTAN before January 1, 2013), ISIN number, coupon rate, first date on which the quotes for the security are available, expiration date of the security, term-to-maturity of the bond, and the total number of available observations for the security.

The expiration dates of BTANs and OATs usually fall on the 12th and 25th day of a particular month, respectively. Although Table A1 shows that the first quote for the first seven bonds is July 1, 1987, we found that between July 1987 and October 1987 there is a significant number of days when there are fewer than six securities' quotes available on a particular day.[13] For this reason, we start our curve estimation on October 22, 1987. Following this date, we always have six or more quotes per trading day, which allows us to estimate the curve every day. We use bid prices in line with GSW: We found that the cross-sectional average of OAT bid-ask spreads is around 7 euro cents, quite a reasonable level for a relatively recent market.

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[9] According to Af2i - the Association Française des Investisseurs Institutionnels, institutional investors are investors that collect private funds and are required to invest a large part of their stake with a long-term perspective: Translated by the authors, a definition from Af2i is *Savings organizations that place their funds on the markets for their own account or that of their customers (individuals, pension funds, policyholders, …). These organizations are institutionally required to hold a significant fraction of their resources in long-term investments. […] These institutional investors present various institutions (pension funds, insurance companies insurance, mutual funds, associations, foundations, some types of social security funds, and special institutions …).*

[10] In a situation where debt is far larger, see Fig. 1.

[11] Neither OATs nor BTANs are callable. When appropriate, the AFT can try to buy back the debt.

[12] We cross-checked that the information from Bloomberg is consistent with the information in the AFT monthly newsletters.These newsletters are available on the AFT website https://www.aft.gouv.fr/fr/bulletins-mensuels since the January 2010. At the start of our project we manually collected newsletters for earlier years, starting from January 1998, from which we obtained the outstanding notional amount of the OAT market. The January 1998 newsletter contained the OAT notional debt amount that was dated back to December 1993 (start of the sample in Fig. 1). Unfortunately, currently the AFT site provides newsletters only from January 2010. It appears that the information recorded by Bloomberg (especially for bonds issued before 1999) does not necessarily match.

[13] Six quotes is the minimum number of quotes which is necessary to fit the yield curve following Svensson[33] methodology because the Svensson parametric form has six parameters.

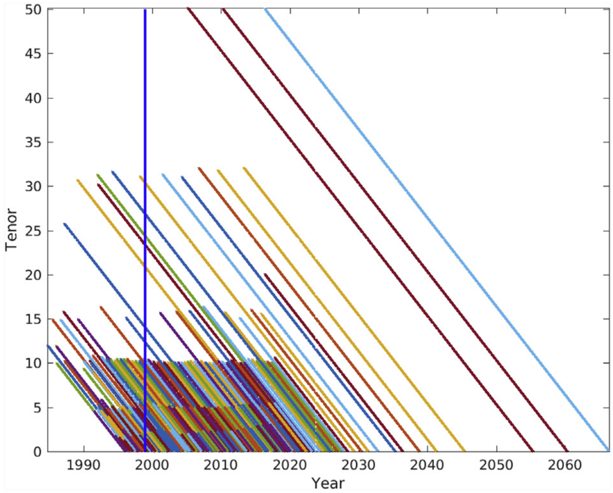


Fig. 2. Maturity Structure of the BTANs and OATs. This figure shows the maturity structure of the French nominal government securities, BTANs and OATs issued from 1984 to 2018. The vertical line corresponds to January 1, 1999, the beginning of the euro-area sample. Source: Bloomberg.

The maturity structure of the French market over our sample period is plotted in Fig. 2. Each line represents one security. The date is shown on the horizontal axis and the remaining time-to-maturity is shown on the vertical axis in years. The upper-left point of the line corresponds to the first date for which the quote is available on Bloomberg. The lower-right point of the line corresponds to the bond expiration date. As one can see from this graph, most of the issuance is concentrated in the maturity range of 5−10 years. An interesting feature of the OAT market (and different from U.S. Treasury securities) is that there are currently three 50-year (ultra-long) bonds, issued in 2005, 2010, and 2016. The vertical line on the figure corresponds to the January 1, 1999—the first trading day in euros in our sample.

4. Methodology

In this section, we first define basic concepts that we use in the paper, then introduce Svensson[33] methodology, describe various filters used for our data set, and discuss our estimation procedure.

4.1. Basic concepts

The first and most basic concept for pricing any fixed-income asset is the discount function or the price of a zero-coupon bond that represents the value at time t of paying € 1 at a future point of time T. We denote this bond price as $B(t,T)$, and it is worth introducing the continuously compounded zero-coupon yield on this bond denoted by $y(t,T)$. The zero-coupon bond price and this zero-coupon bond yield are linked via the relationship

$$B(t,T) = \exp[-y(t,T) \times (T-t)]. \tag{1}$$

or equivalently

$$y(t,T) = -\frac{1}{T-t} \ln B(t,T). \tag{2}$$

Assume now that we observe a number of zero-coupon bond prices. We can then price any coupon-bearing bond. Actually, by using the no-arbitrage argument, the time $t-$ price of a coupon bond maturing in $T-t$ years, promising $N_{c,t}$ identical coupon payments c, and paying €1 in $T-t$ years, is given by

$$P(c,t,T) = \sum_{i=1}^{N_{c,t}} c \times B(t,t_i) + B(t,T). \tag{3}$$

In this formula, t_i stands for the i^{th} coupon payment date and $t_{N_{c,t}}$ is the last payment date. Therefore, $t_{N_{c,t}} = T$. Because OATs and BTANs pay annual coupons, the set of payment dates also satisfy $t_i - t_{i-1} = (t_i - t) - (t_{i-1} - t) = 1$for all $i \geq 1$, that is, two cash flow payments are separated by one year. It is worth noting finally that the face value of French securities is not necessary €1, but this issue is straightforward to address.[14] In what follows, one will denote by Y the yield-to-maturity of the coupon bond; Y makes the present value of future (annual) cash flows equal to the coupon bond price. And one has

$$P(c,t,T) = \sum_{i=1}^{N_{c,t}} \frac{c}{(1+Y)^{t_i-t}} + \frac{1}{(1+Y)^{T-t}} \tag{4}$$

It is straightforward to convert this yield to maturity into its continuously compounded counterpart ($y = \ln(1+Y)$). Another popular way among market participants is to express and quote bond prices in terms of par yields. The par yield over a certain horizon T is the coupon rate at which a coupon bond security maturing at T will trade at par. Setting the price of the coupon bond in equation (3) to $p(c,t,T) = \$1$, we obtain the solution for the coupon rate $c \equiv y^c(t,T)$:

$$y^c(t,T) = \frac{1 - B(t,T)}{\sum_{i=1}^{N_t} B(t,t_i)}. \tag{5}$$

While zero-coupon yields represent a mathematically simpler concept, market participants usually quote yields to maturity on coupon-bearing bonds and use par yields. We compute both par yields and zero-coupon yields in this paper.

The yield curve can also be expressed in terms of forward rates. A forward rate is the rate that an investor is able to lock in some time in the future by trading zero-coupon bonds of different horizons now. For example, if an investor wishes to lock at time t in an $m-$ period rate between T and $T+m$ years in the future, this forward rate, denoted as $f(t,T,m)$, can be obtained as follows:

$$f(t,T,m) = -\frac{1}{m}\ln\frac{B(t,T+m)}{B(t,T)} = \frac{1}{m}((T+m)y(t,T+m) - Ty(t,T)). \tag{6}$$

Taking the limit $m \rightarrow 0$, we obtain the instantaneous forward rate $f(t,T,0)$:

$$f(t,T,0) = \lim_{m\rightarrow 0} f(t,T,m) = y(t,T) + Ty'(t,T) = -\frac{\partial}{\partial T}\ln P(t,T). \tag{7}$$

Equation (7) essentially means that if the forward rate is above (below) the yield at a certain maturity, then the yield curve is upward (downward) sloping at that maturity. The zero-coupon yield over time $T-t$ can be thought of as a continuous roll-over of the instantaneous forward rate investments and therefore can be expressed as the average of the forward rates over the horizon $T-t$:

$$y(t,T) = \frac{1}{T-t}\int_t^T f(t,x,0)dx. \tag{8}$$

It is useful to think of the forward rates rather than yields themselves as describing the yield curves. For example, the 30-year OAT yield can be represented as the average of the one-year forward rates over 30 years. While forward rates at shorter horizons might be influenced by cyclical factors (such as monetary policy expectations), at longer horizons forward rates appear to be reflecting more fundamental factors like changes in the risk attitudes of investors. Zero-coupon yields combine information about these two types of factors in one number, while forward rates disentangle this information.

Finally, we use the concept of the modified duration in our yield curve estimation:

[14] In contrast, nominal Treasury securities pay semiannual coupons so the cashflows would be in this case $c/2$.

$$D = \frac{D_{Mac}}{1+Y}, \quad (9)$$

where Y stands for the yield-to-maturity and D_{Mac} is the Macaulay duration. It is well known that the Macaulay duration is the weighted average of the time (in years) that the investor must wait to receive the cash flows of a coupon bond. It is computed by

$$D_{Mac} = \frac{1}{p(c,t,T)}\left[\sum_{i=1}^{N_{c,t}}(t_i - t)\times c\times B(t,t_i) + (T-t)\times F\times B(t,T)\right]. \quad (10)$$

The modified duration is very popular among participants because it connects more explicitly the change in yields to the change in prices, see, e.g. ref.[28] for additional information about durations.

4.2. Svensson methodology

We broadly follow GSW to fit the nominal (BTAN- and OAT-based) zero-coupon yield curves using the Svensson[33] methodology, which is commonly viewed as an augmented (and therefore more flexible) version of the Nelson and Siegel[29] approach. The Svensson curve fitting approach relies on the premise that the curve associated with the instantaneous forward rates $f(t,m,0)$ m periods ahead at time t and is correctly described by the following functional form:

$$f(t,m;\Theta) = \beta_{t,0} + \beta_{t,1}\exp\left[-\frac{m}{\tau_{t,1}}\right] + \beta_{t,2}\frac{m}{\tau_{t,1}}\exp\left[-\frac{m}{\tau_{t,1}}\right] + \beta_{t,3}\frac{m}{\tau_{t,2}}\exp\left[-\frac{m}{\tau_{t,2}}\right], \quad (11)$$

where $\Theta = \{\beta_{t,0}, \beta_{t,1}, \beta_{t,2}, \beta_{t,3}, \tau_{t,1}, \tau_{t,2}\}$ are six Svensson parameters are estimated daily. For any t (we are removing subscript t hereafter for brevity), the instantaneous forward rate (11) starts at the level $\beta_0 + \beta_1$ at a horizon zero and converges to β_0 as m approaches infinity. Thus, $\beta_0 + \beta_1$ and β_0 have a natural interpretation of the short rates at the short and long end of the yield curve. The functional form (6) is also flexible enough to accommodate two potential humps in the shape of the forward curve (observed, for example, in U.S. Treasury forward rate curves). The third and fourth terms in the above equation control two humps of the curve, given that the respective parameters $(\beta_2, \tau_1)$and (β_3, τ_2) specify the size and the location of these humps.

Zero-coupon yields are obtained by integrating $f(t,m;\Theta)$ over the interest rate horizon $[t, t+m]$ using (8) and (11):

$$y(t,t+m;\Theta) = \beta_{t,0} + \beta_{t,1}\frac{1-e^{-\frac{m}{\tau_{t,1}}}}{\frac{m}{\tau_{t,1}}} + \beta_{t,2}\left[\frac{1-e^{-\frac{m}{\tau_{t,1}}}}{\frac{m}{\tau_{t,1}}} - e^{-\frac{m}{\tau_{t,1}}}\right] + \beta_{t,3}\left[\frac{1-e^{-\frac{m}{\tau_{t,2}}}}{\frac{m}{\tau_{t,2}}} - e^{-\frac{m}{\tau_{t,2}}}\right]. \quad (12)$$

Therefore, for a given set of parameters Θ for any date t, the Svensson curve (11) defines the forward rate curve. From the latter, we can obtain the zero-coupon yields using (12) and par yields defined in (5). We use zero-coupon yields to price zero-coupon bonds and, consequently, compute the model-implied prices of the OAT coupon securities with a specific coupon rate and a specific maturity date. The next two subsections discuss certain data filters and estimation details.

4.3. Filters

In fitting the curve, we impose the following filters, following GSW.

1. First, we confine our database only to regular bonds with no special features. We therefore exclude floating-rate bonds, inflation-linked bonds, and bonds that were denominated in currencies other than FFs, ECUs, or euros. In addition, following GSW, we exclude STRIPS of OATs known as the "*certificats zéro-coupon fongibles*" that are available on the secondary market.

2. We exclude BTFs from our investigation. Using the arguments of Duffee[9] regarding the variation in the U.S. Treasury bill yields, it is not clear how innocuous is the use of the BTFs.[15]
3. We exclude the short-duration securities—that is, all securities with less than 12 months to maturity—to prevent particular institutional details, unrelated to movements reflecting fundamentals, to affect the fit of the curve. For example, some long-term asset (pension or insurance) fund managers tend to sell off shorter-duration bonds in rebalancing their portfolios.[16]
4. Unlike GSW, we did not exclude the on-the-run bond (that is, the most recently issued bond) and the first off-the-run bond (that is, the most recent bond after the on-the-run bond).[17]
5. We also eliminated several abnormal quotes for two securities. Security FR0000041410 (issued July 1, 1987 - matured October 8, 1996) has abnormal quotes from October 30, 1987 to December 1, 1987 (21 day) that we eliminated. Security FR0000570509 (issued May 8, 1996 - matured April 25, 2006) has three abnormal quotes on February 19, 21, 25, 2002, which we eliminated as well.[18]

According to the above filters we eliminated 32,409 quotes. Therefore, we reduced our sample of 315,877 quotes to 283,468 quotes, about 10 percent of our sample.

4.4. Estimation

We collect at time t a set of observed bond prices $P^o(c_k, t, T_k), \quad k = 1, \ldots, N_t$ where c_k and T_k are the coupon and maturity of the bond k, respectively, and N_t is the number of bond prices available on day t. Observed and model bond prices are related via the following relationship:

$$P^o(c_k, t, T_k) = P(c_k, t, T_k; \Theta_t) + \varepsilon_{t,k}, \tag{13}$$

where the vector of error terms $\varepsilon_t' = (\varepsilon_{t,1}, \ldots, \varepsilon_{t,N_t})$ has a zero mean and a diagonal covariance matrix with possibly different variances on the diagonal. The set of parameters Θ_t is estimated by minimizing a weighted sum of squared errors whose weights are the inverses of the squared modified duration D defined in equation (9). More formally, the solution set satisfies

$$\widehat{\Theta}_t = \underset{\Theta_t}{\operatorname{argmin}} \sum_{k=1}^{N_t} \left[\frac{P^o(c_k, t, T_k) - P(c_k, t, T_k; \Theta_t)}{D_k} \right]^2 \tag{14}$$

where D_k is the modified duration of the bond k. This particular weighting scheme is an appropriate way to deal with the nonlinear relation between yields and prices (see ref.[33,17]). As explained by GSW (see their footnote 4 on page 2296), this way to proceed avoids converting bond prices into yields and therefore speeds up the calibration exercise.[19]

We place some constraints on the parameters according to their economic meaning. For instance, τ_1, τ_2, and β_0 are constrained to be positive numbers in our estimation. Note that we do not constrain $\beta_0 + \beta_1$ to be positive to allow for the short negative rates, a feature prevalent in the advanced economies toward the end of our sample.

We then compute, at any time t, mean absolute error (MAE) of the model fit for particular maturity bins. $MAE_t(\tau)$ averages the absolute differences between the observed and Svensson predicted yield-to-maturity of the bonds within a particular maturity bin τ:

[15] G. Duffee documents idiosyncratic variation in the U.S. Treasury bills in part related to a common component in Treasury bill yields that is not shared by yields on other instruments, such as short-maturity privately-issued instruments or longer-maturity Treasury notes and bonds. By excluding BTFs, we also avoid selecting a particular approach among the (discordant and sometimes debatable) empirical strategies found in the literature to deal with the French short-term debt securities. For example, Ricart and Sicsic[32] select BTFs, BTANs, and OATs with time-to-maturity larger than one month and one year, respectively (for liquidity concerns), and they force the yield curve to fit exactly the yield of the next-to-repay BTF.

[16] GSW exclude bonds with remaining time to maturity of less than 18 months. We adopted a shorter — 12-month — threshold to have more observations in the cross-section because the OAT market initially used to have significantly fewer bonds than the market for the U.S. Treasury securities, which has close to 300 securities. That said, we also tried an 18-month threshold and did not find significant differences.

[17] In fact, we have fit the curve excluding these two bonds but did not find significant differences. We discuss these findings in detail in Section 6.

[18] We confirmed with the Bloomberg customer support team that these quotes are abnormal.

[19] Note that some other authors use more standard durations. For example, HPW use the Macauley duration in estimating the curve.

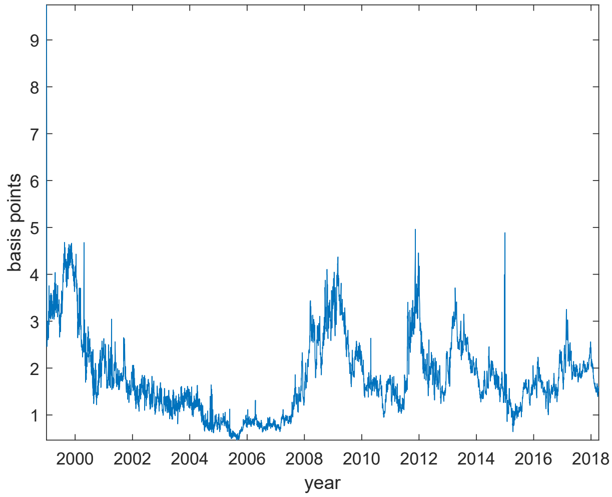


Fig. 3. Fitting Errors. This figure shows the total fitting error implied by the Svensson[33] model. The fitting error is computed as the mean absolute error between the predicted and the market yields across all available BTAN and OAT securities on a particular day. The fitting errors are shown in basis points. Sample period: January 1, 1999 to April 10, 2018. Frequency: Daily.

$$MAE_t(\tau) = \frac{1}{N_t(\tau)} \sum_{k=1}^{N_t(\tau)} |y^o(c_k, t, T_k) - y(c_k, t, T_k; \widehat{\Theta}_t)|, \tag{15}$$

where $N_t(\tau)$ is the number of bonds within a particular maturity bin τ; $y^o(c_k, t, T_k)$ and $y(c_k, t, T_k; \widehat{\Theta}_t)$ are the observed and fitted yield-to-maturity of the bond k, respectively.

5. Results

In this section we discuss our estimation results—namely, we discuss the model fit and the implied term structure of OAT interest rates.

5.1. Model fit

Fig. 3 plots the time series of the overall fitting errors. The measure of the overall fitting error on a particular day is the average of absolute errors between the predicted and market yields across all available securities that day. It is computed by

$$MAE_t = \frac{1}{N_{b,t}} \sum_{i=1}^{N_{b,t}} |\widehat{y}(t,i) - y(c, T_i; \widehat{\Theta}_t)|, \tag{16}$$

or equivalently, $MAE_t = \frac{1}{N_{b,t}} \sum_{\tau=1}^{N\tau} N_t(\tau) MAE_t(\tau)$, where $N\tau$ is the number of maturity ranges (we also call them bins interchangeably). We show these errors for our benchmark sample, which is the sample period after the euro was introduced, from January 1, 1999, onwards.[20] One can see that the model does a very good job of fitting the cross section of OAT securities with only six parameters. Indeed, pricing errors do not exceed 5 basis points in the euro sample. This magnitude is definitely reasonable and consistent with GSW findings of the U.S. Treasury securities yields curve in the post-1980s sample period. In particular, the model fit has been improving from the onset of the euro area until the beginning of the 2007-08 subprime mortgage crisis period and the following 2008-09 GFC period. Then, the model fit has deteriorated temporarily. Consequently, the errors spiked again during the 2011-12 sovereign bond

[20] We discuss the behavior of the model in the pre-euro period in Section 8.

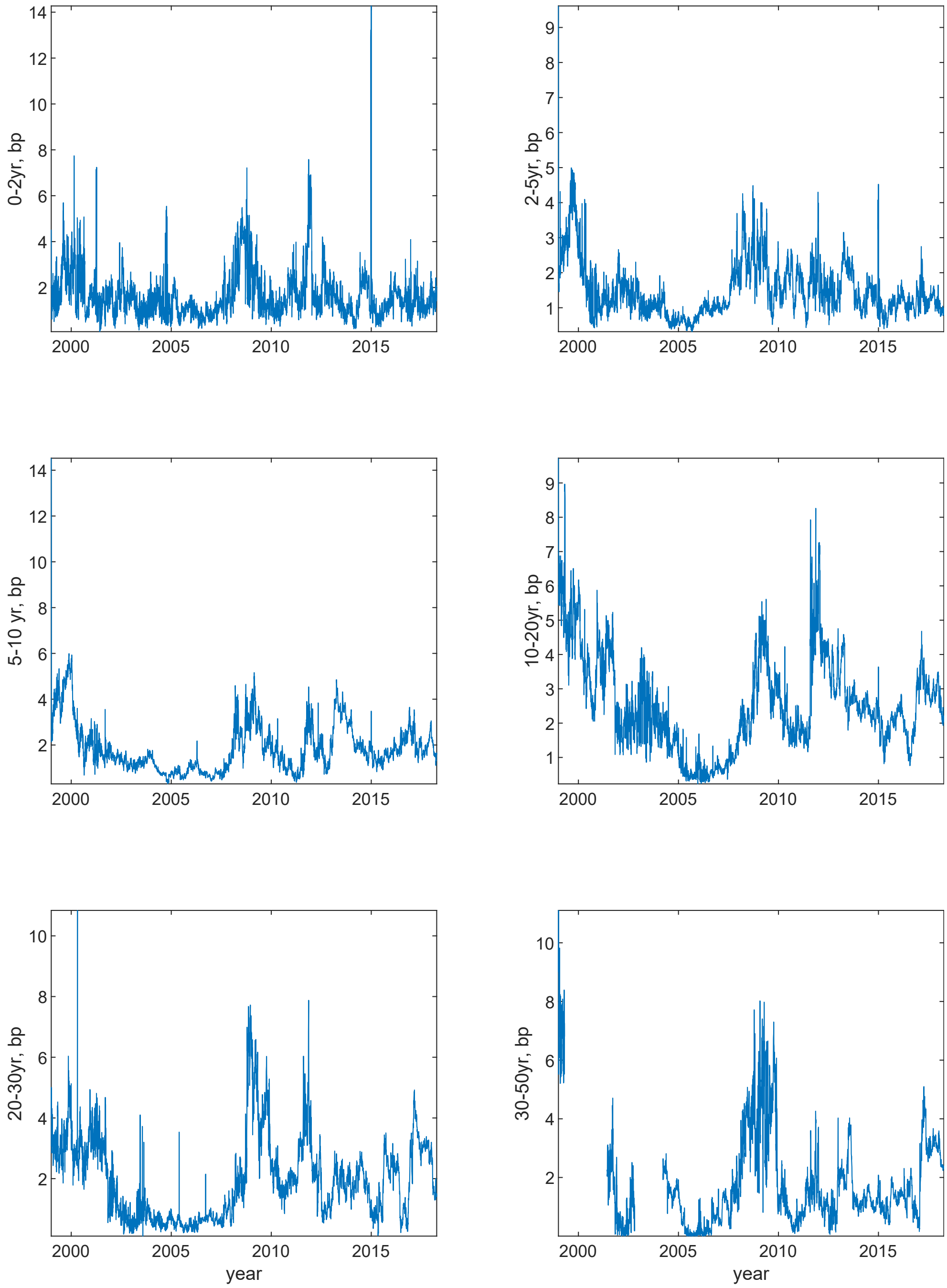


Fig. 4. Maturity-specific Fitting Errors. This figure shows the fitting errors of the Svensson[33] model implied by the BTANs and OATs. The fitting error is computed as the mean absolute error between the predicted and the market prices in a certain maturity bin. We report the errors for six maturity bins: 0-2-year, 2-5-year, 5-10-year, 10-20-year, 20-30-year, and 30-50-year bin. The fitting errors are shown in basis points. Sample period: January 1, 1999 to April 10, 2018. Frequency: Daily.

crisis (when, in particular, France has lost its AAA Standard & Poor's rating on January 9, 2012). A possible explanation for such variation throughout the euro sample period, consistent with the views of OAT market participants, is that the liquidity and attractiveness of OATs has generally improved over time after the launch of the euro area but deteriorated during the turmoil of the global financial and sovereign bond crises.

Table 1
Summary Statistics of the Svensson Model Fitting Errors. The table reports descriptive statistics of the daily fitting errors for securities in the indicated maturity bins for the full sample period, from October 22, 1987 to April 10, 2018 (Panel A) and for the euro sample period, from January 1, 1999 to April 10, 2018 (Panel B). The fitting errors are mean absolute errors between observed and predicted yields of the Svensson[33] model. The errors are reported in basis points. Frequency: daily.

	0–2yr	2–5yr	5–10yr	10–20yr	20–30yr	30–50yr
Panel A: Full sample: Oct 22, 1987 - April 10, 2018						
Mean	2.45	4.24	5.98	4.59	4.63	2.33
Max	30.59	43.54	40.64	44.94	37.60	25.40
Min	0.00	0.00	0.30	0.00	0.01	0.00
Std. Dev.	3.82	6.29	7.31	4.48	6.05	4.07
Panel B: Euro sample: Jan 1, 1999 - April 10, 2018						
Mean	1.62	1.48	1.87	2.53	1.98	1.45
Max	14.27	9.61	14.53	9.72	10.84	11.11
Min	0.07	0.32	0.30	0.23	0.11	0.00
Std. Dev.	1.05	0.77	1.07	1.40	1.36	1.57

Fig. 4 plots the time series of fitting errors (15) for six maturity bins: 0–2 years, 2–5 years, 5–10 years, 10–20 years, 20–30 years, and 30–50 years. Interestingly, the fitting error magnitude and behavior differ according to the maturity interval. In particular, fitting errors in the 2–5 years maturity range (top-right chart) appear to be notably higher than overall during the U.S. subprime mortgage crisis period, while fitting errors in the 5–10 years range indicate the deterioration in the model fit during the 2011-12 sovereign debt crisis in the euro zone. For longer-term securities (the low row of panels in Fig. 4), the model fit has worsened, particularly during the GFC period.

In addition, we report descriptive statistics of the overall fitting errors and fitting errors for different maturity bins in Table 1 for the full sample period (Panel A) and the euro sample period (Panel B). The numbers confirm our visual representation in Figs. 3 and 4 that fitting errors became smaller in the euro period (on average not exceeding 3 basis points) than in the full sample period (on average 5 basis points). While the maximum fitting error has reached 44 basis points in the pre-euro period, it was only 13 basis points in our benchmark period. The fit also became much more stable in the euro period: volatility of the fitting errors did not exceed 2 basis points during this period of time, but it was very high before the launch of the euro (as demonstrated by the full-sample average of 8 basis points). Finally, we observe the worst fit in the full sample period in the 5–10 years maturity range of OAT securities, while in the euro sample we observe it for the 10–20 years maturities.

Fig. 5 shows the estimated Svensson nominal par yield curve on three different dates, which we picked in the three broadly defined periods: on March 25, 2003 (during the "before the crisis" period), on June 10, 2008 (during the "crisis" period), and on April 2, 2018 (during the "after the crisis" period). The left-hand side of the figure shows the model-implied par yield curve along with observed (blue round circles) and predicted (red crosses) continuously compounded yields. The predicted yields are computed using parameters that are estimated using BTAN/OAT quotes on the indicated day. The right-hand side of the figure shows security-specific pricing errors computed as differences between observed and predicted yield to maturity. Thus, positive errors correspond to higher observed than predicted yields and, thus, lower observed than predicted bond prices. Therefore, in this case the model overprices bonds relative to observed prices. Alternatively, negative errors correspond to model underpricing relative to observed prices. Overall, we find that before and after the crisis, the range of values for the fitting errors remains relatively narrow, not exceeding 3 basis points in absolute values. However, during the crisis period, the fit of the curve worsened notably, likely reflecting a shortage of arbitrage capital and overall deteriorated market functioning.

5.2. The term structures of zero-coupon and forward rates

We then investigate the term structures of zero-coupon and forward rates to document the different shapes and behaviors of the French yield curves we estimated.

5.2.1. Shapes of the yield curve

Table 2 reports the summary statistics of the fitted zero-coupon rates and associated instantaneous forward rates implied by the price quotes of BTAN and OAT securities. For six different horizons, it displays the average, maximum,

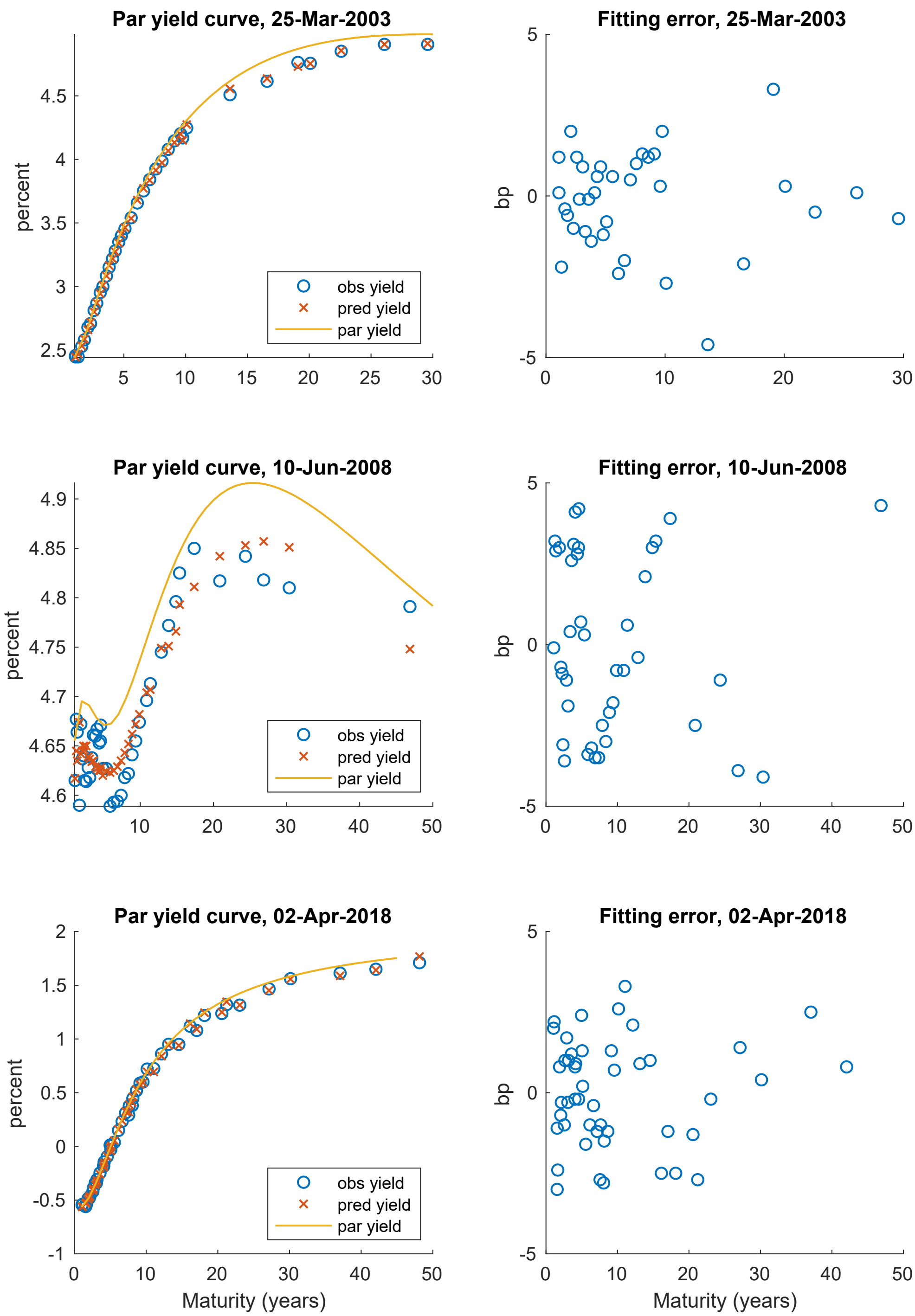


Fig. 5. Par Yield Curve. This figure shows the fitted par yield curve and the fit of individual securities (left charts) along with security-specific fitting errors (right charts) of the securities for three days in our sample: March 25, 2003, June 10, 2008, and April 2, 2018. The fitted curve is reported in annualized percent, the fitting errors are reported in basis points.

and minimum values; volatility; skewness; kurtosis; and the autoregressive of order 1 coefficient, AR (1). On average, zero-coupon rates increase up to a horizon of 30 years and forward rates increase up to a horizon of 10 years. The volatility of zero-coupon rates is decreasing at short-to-intermediate horizons and then increasing. However, the

Table 2
Summary Statistics of Fitted Yields. This table reports summary statistics of the Svensson[33] fitted zero-coupon yields (Panel A) and instantaneous forward rates (Panel B) for 2-, 5-, 7-, 10-, 30-, and 50-year maturities implied by our sample of the nominal BTAN and OAT securities. All statistics are reported in the annualized percent. Sample: January 1, 1999 to April 10, 2018. Frequency: daily.

	2yr	5yr	7yr	10yr	30yr	50yr
Panel A: Zero-coupon rates						
Mean	1.9475	2.5308	2.8727	3.2722	4.0161	3.8628
Max	5.1929	5.2737	5.3698	5.6587	6.3592	5.9507
Min	−0.6854	−0.4390	−0.2281	0.0812	1.0099	1.3050
Std. Dev.	1.7181	1.6413	1.5650	1.4749	1.2715	1.0492
Skewness	0.0232	−0.3253	−0.4724	−0.6011	−0.5400	−0.5174
Kurtosis	1.6574	1.8355	2.0109	2.2387	2.4300	2.5161
AR (1) coeff	0.9995	0.9994	0.9994	0.9993	0.9990	0.9966
Panel B: Forward rates						
Mean	2.3113	3.4578	3.9629	4.3897	4.0298	3.2978
Max	5.3084	5.8455	6.1765	6.6639	6.4462	5.7061
Min	−0.6274	0.0282	0.4885	0.9842	1.4695	1.2821
Std. Dev.	1.7544	1.5161	1.3891	1.2969	1.0297	0.7022
Skewness	−0.2458	−0.7551	−0.8853	−0.8460	−0.1960	0.2764
Kurtosis	1.7401	2.3760	2.7318	2.8629	2.4861	2.9585
AR (1) coeff	0.9993	0.9992	0.9991	0.9989	0.9959	0.9373

volatility of forward rates is strictly decreasing with the horizon. We find nevertheless that the zero-coupon rate curve has had different shapes over our sample period as shown in Fig. 6, which plots zero-coupon yield curves and instantaneous forward rate curves on the same days as Fig. 5 does—namely, on March 25, 2003, June 10, 2008, and April 2, 2018. The zero-coupon rate curves appear on the left side of the figure and the forward rate curves are on the right side of it. These plots show various shapes yield curve shapes implied by the OATs. For example, the term structure on March 25, 2003, is upward-sloping until about the 30-year maturity point, after which it slopes down. This is a typical behavior of the term structure, as the very long end of the curve is affected by convexity and can be captured by the second hump in the Svensson function (6). Indeed, on March 25, 2003, the zero-coupon and forward yield curves have only one hump, but they experience changes in the sign of curve convexity (first negative and then positive for very long horizons). In general, the Svensson specification allows the term structure to have two humps and thus the Svensson formulation is more flexible relative to the Nelson-Siegel model.

The yield curve and forward rate curve on June 10, 2008, have two humps. In addition, the term structure for both zero-coupon and forward curves is downward-sloping, likely indicating worsening economic conditions. This in turn supports the widespread view that the financial crisis was indeed global and affected the growth prospects in many advanced economies, including France. Finally, toward the end of our sample, and as indicated by the graph on April 2, 2018, the yield curve becomes upward sloping.

5.2.2. *Dynamics of the yield curve*

Fig. 7 plots 2-, 10-, and 30-year zero-coupon yields in our sample, from 1988 to 2018. It is obvious that the movements in the rates at these three tenors are highly correlated, although not perfectly correlated. Table 3 reports correlations among rates of different maturities, which vary from about 0.85 to about 0.99. The correlations are computed for daily series in the euro sample. In particular, the table shows that the correlations between the 2- and 10-year, 10- and 30-year, and 2- and 30-year zero-coupon rates are 0.92, 0.98, and 0.85, respectively. Fig. 7 also indicates that all series declined following the peak of the GFC. In the beginning of 2015, the 2-year yields reached the zero-lower bound and declined further down into negative territories from then on, supporting the trend of declining and negative interest rates in other advanced economies in Europe.[21]

Turning to specific maturities, in our sample period the 2-year yield stayed in the range of 3 percent prior to the GFC period. It shortly reached five percent around 2001. The 2-year yield rose during the pre-crisis period in 2006 and 2007 and then started declining almost monotonically from about the 4 percent level. Later in our sample, the 2-year

[21] Our OAT-implied zero-coupon yields and those available at the ECB website have correlations close to 1 and thus have also shown similar trends, although ECB reported yields were slightly higher during the sovereign financial crisis.

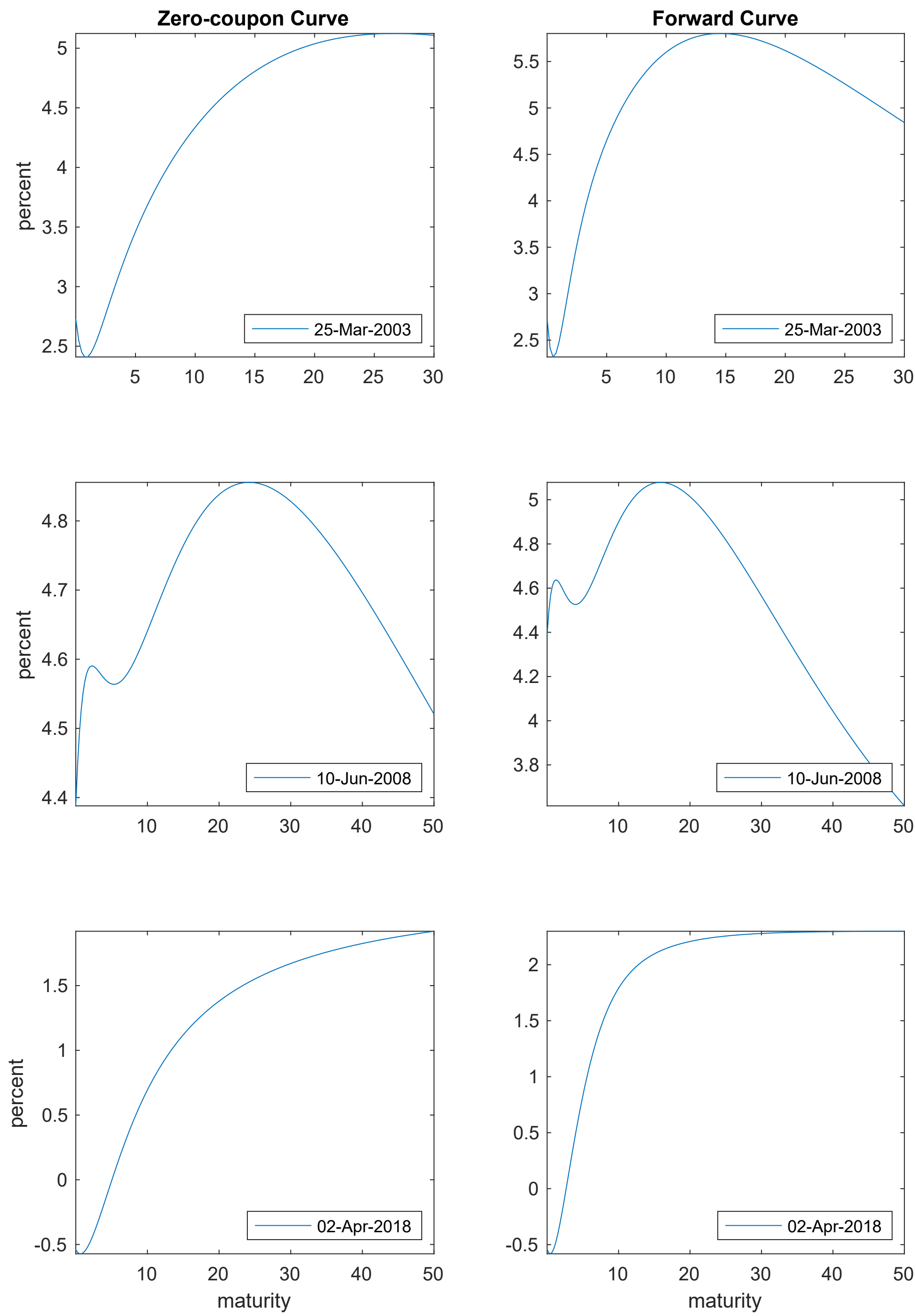


Fig. 6. Term Structures of Zero-Coupon Rates and Forward Rates. This figure shows Svensson[33] zero-coupon yield and instantaneous forward rate term structures on three days in our sample: March 25, 2003, June 10, 2008, and April 2, 2018.

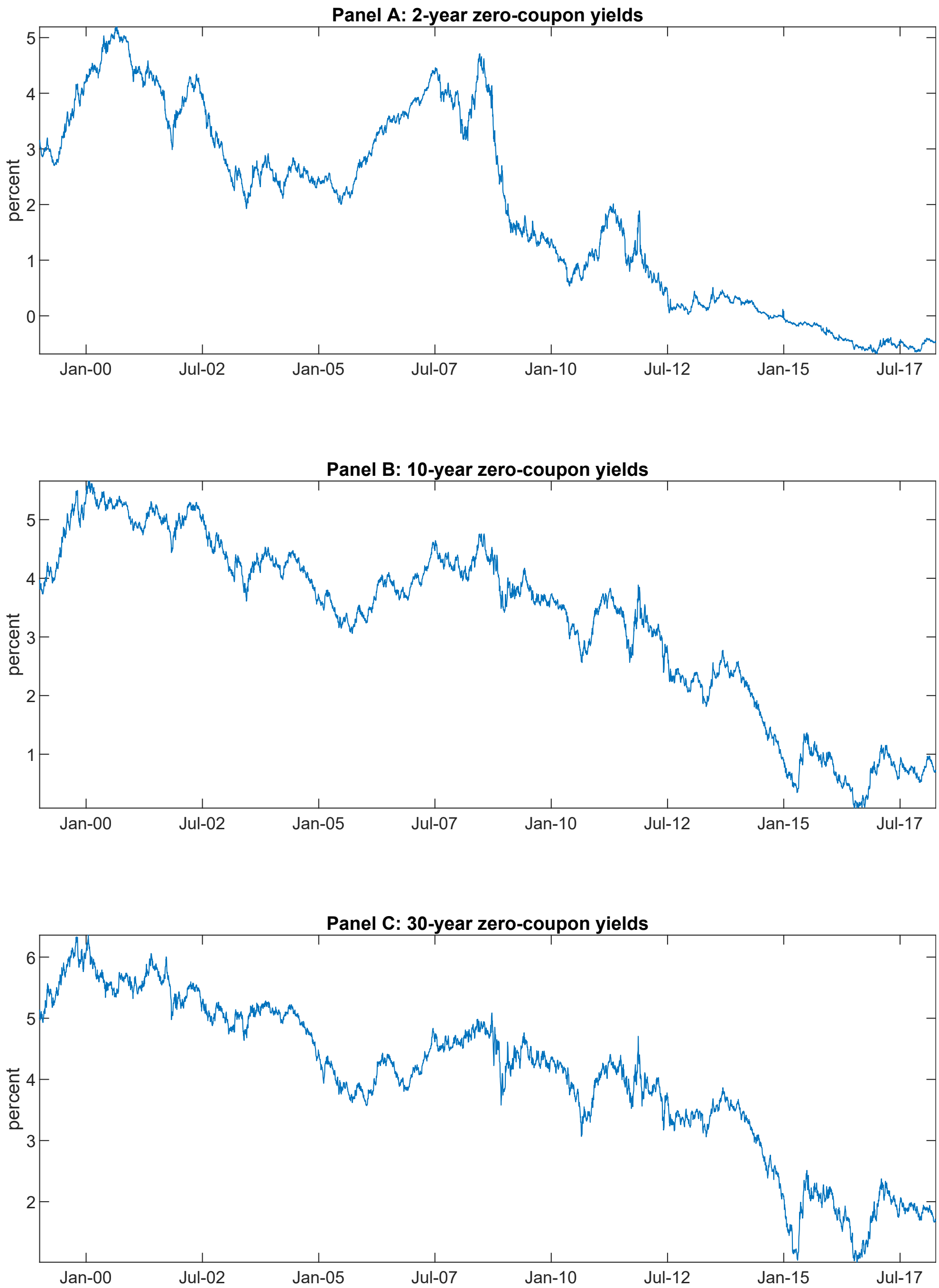


Fig. 7. Time Series of Zero-Coupon Yields. This figure shows the time series of the Svensson[33] fitted 2-, 10-, and 30-year zero-coupon yields implied by the price quotes of BTANs and OATs from January 1, 1999 to April 10, 2018, at daily frequency.

Table 3
Correlation. This table reports correlations of Svensson[33] fitted zero-coupon yields (Panel A) and instantaneous forward rates (Panel B) for 2-, 5-, 7-, 10-, 30-, and 50-year maturities implied by our sample of the nominal BTAN and OAT securities. Sample: January 1, 1999 to April 10, 2018. Frequency: daily.

	2yr	5yr	7yr	10yr	30yr	50yr
Panel A: Zero-coupon rates						
2yr	1.0000	0.9775	0.9546	0.9237	0.8726	0.8480
5yr		1.0000	0.9955	0.9813	0.9414	0.9148
7yr			1.0000	0.9950	0.9637	0.9380
10yr				1.0000	0.9811	0.9570
30yr					1.0000	0.9873
50yr						1.0000
Panel B: Forward rates						
2yr	1.0000	0.9383	0.8872	0.8520	0.8608	0.4257
5yr		1.0000	0.9895	0.9675	0.9071	0.5148
7yr			1.0000	0.9920	0.9114	0.5383
10yr				1.0000	0.9215	0.5394
30yr					1.0000	0.6889
50yr						1.0000

yield increased shortly in 2010 and then declined sharply again around the 2011-12 sovereign debt crisis in Europe. The 10- and 30-year yields also declined similarly to the 2-year yield starting from about 4 or 5 percent levels depending on the maturity. At the end of the sample period, the 10- and 30-year zero-coupon rates had values of around 1 and 2 percent, respectively. We leave it to further research to investigate to what extent the decline in OAT-implied rates was due to the decline in expected short-term rates, the decline in term premiums, or both.

5.3. Factors of the yield curve

We investigate the dynamics of the yield curve by running a principal components analysis (PCA). It is widely known that most variation in U.S. Treasury yields can be explained by a few factors—namely, the first three principal components (PCs) of the yield curve, loosely labeled as the level, slope, and curvature factors (see ref.[26,6]). We also derive the principal components from 1- to 10-year zero-coupon OAT yields in the 1999–2018 sample. According to Table 4, the first principal component explains 97.56 percent of the variation in OAT yields, and the second one explains 2.34 percent. Naturally, the rest of the yield curve variation is explained by the third and higher-order principal components.

Fig. 8 plots PC factor loadings with non-normalized variance (Panel A) and the unit variance (Panel B). From the figure it is obvious that the first PC is essentially a level factor because the yields at all maturities load similarly on this factor (the blue curve is roughly flat across maturities). The second PC essentially captures the slope factor (the red curve) because the loadings on short- and long-term maturities have opposite signs, while the relationship between the loadings and maturities remains monotonic. Finally, the third PC factor is close to zero at all maturities (the yellow curve on Panel B) but can be interpreted as the curvature factor.

The left-hand side of Fig. 9 shows the times series for the first three principal components while the right-hand side shows the level, slope, and curvature computed directly using fitted zero-coupon yields. For the level, we use the 10-year zero-coupon yield; for the slope, we take the difference between the 10- and 2-year zero-coupon yields, and for the curvature, we take twice the 5-year zero-coupon yield minus the sum of the 2- and 10-year zero-coupon yields. As seen from the picture, both principal components on the right-hand side and level, slope and curvature computed directly from fitted yields look quite similar. Indeed, the correlation between the first PC and the 10-year yield is close to 98 percent; between the second PC and our slope — close to 93 percent; and finally, correlation between the third PC and the curvature is lower, but it is still notable, around 53 percent.[22]

[22] Note that we cannot proxy the level, slope, and curvature using Svensson coefficients because they do not have the same meaning as the Nelson-Siegel coefficients as Diebold[8] describe.

Table 4
Principal Component Decomposition. This table reports the percent of variance in Svensson[33] fitted zero-coupon yields explained by the first three principal components. Full Sample: October 22, 1987 to April 10, 2018; Euro Sample: January 1, 1999 to April 10, 2018. Frequency: daily.

PC	Full Sample	Euro Sample
PC1	0.9570	0.9755
PC2	0.0401	0.0235
PC3	0.0027	0.0009

The level factor shows downward trend in French interest rates, consistent with declines in other advanced economies. Also, it has become slightly negative at the end of this period. This is in line with declining zero-coupon yields, shown on Fig. 7. The slope declined notably, albeit with significant variations, following the Global Financial Crisis. In the United States, the slope factor is known to be an important predictor of future GDP growth. In particular, flattening of the yield curve is associated with a slowdown in future economic activity (See Ang et al[3]). Finally, the curvature factor is also highly time-varying, although this variation appears to be on a much smaller scale in absolute values. Thus, the third factor appears to be a relatively less important factor given that it explains less than 1 percent of the variation in yields in our sample.

6. Is there any on-the-run premium on the French bond market?

In this section we explore the phenomenon of the on-the-run premium on the French government bond market. The phenomenon refers to the fact that, in general, newly issued bonds are sought by market participants and therefore are more expensive than other bonds with similar time-to-maturity characteristics that were issued earlier. The existence of the sizeable on-the-run, or liquidity, premium has been well established on the U.S. nominal Treasury securities market (see ref.[14,31]). To assess how large the on-the-run premium could be on the French market, we follow the GSW approach.

We start with the definition of the premium. The most recently issued security is called the "on-the-run" security and the one issued right before it is called the "first off-the-run" security. Thus, we define the spread between the on-the-run security and the first off-the-run security for a particular maturity n as:

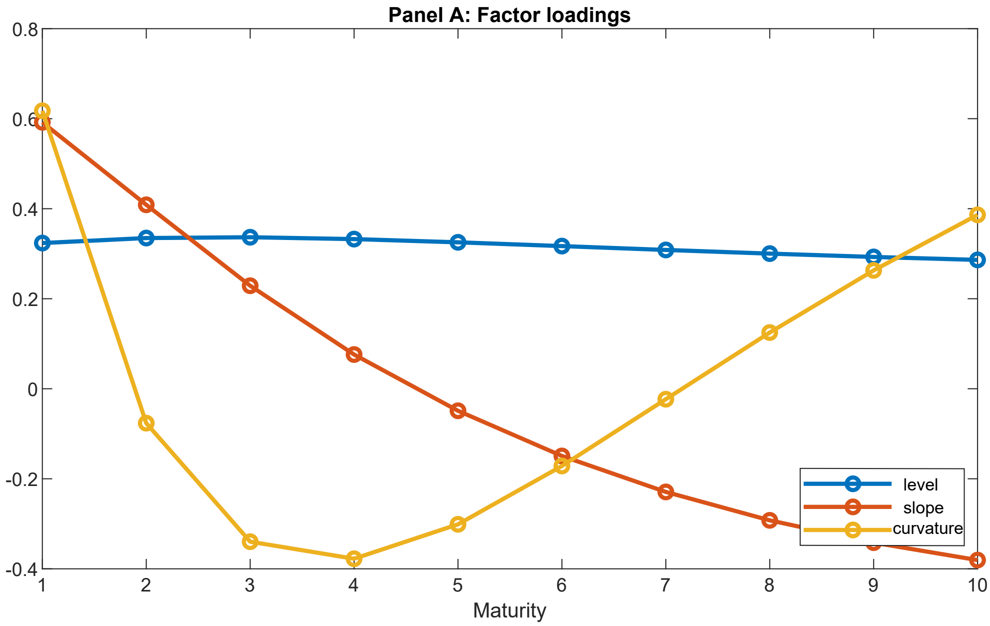
$$OTR_{t,n} = y_{t,n}^{\mathbf{off-the-run}} - y_{t,n}^{\mathbf{on-the-run}}. \tag{17}$$

This is a traditional definition of the OTR — relevant for the U.S. Treasuries market — that we adapted for the French OAT market. According to this definition, the observed yield-to-maturity of the on-the-run security is compared to the predicted yield-to-maturity of a so-called *synthetic* bond with identical characteristics (expiration date, coupon rate, and coupon frequency). This is supposedly the only way to proceed on the French market. Consequently, the OTR defined in (17) is a pure abstraction in the French market compared to the U.S. market for Treasury securities. The spread in (17) is expected to be positive when market participants seek the on-the-run security that would be traded, therefore, at a higher price (and a lower yield) than the first off-the-run security, everything else being equal.

To fit the yield curve for this purpose, we exclude from the cross section of available bonds both the on-the-run and the first off-the-run bonds from each maturity range: 1-to-4-, 5-to-6-, 8-to-12-, 15-to-16-, and 20-to-32-year ranges. We re-fit the Svensson par yield curve every day without these on-the-run securities, obtain the predicted yield of the synthetic security, compare to the observed yield of the security with the same characteristics and compute the on-the-run premium according to equation (17).[23]

Fig. 10 plots the time series of the on-the-run premium for the 5- and 10-year maturity bonds. We compute the premium for the current on-the-run bond, then for the next on-the-run bond when the new bond is issued, and so on. Thus, we obtain the time series of the on-the-run premium, as we roll-over the on-the-run securities in our sample. Therefore, the on-the-run premium is not related to a particular bond, but only to a particular-maturity security. As it is

[23] Note that we do not exclude any on-the-run securities in our baseline yield curve fitting exercise, primarily because we find that on-the-run premium does not exist on the French OAT market. See filter No. 4 in Section 4.3.



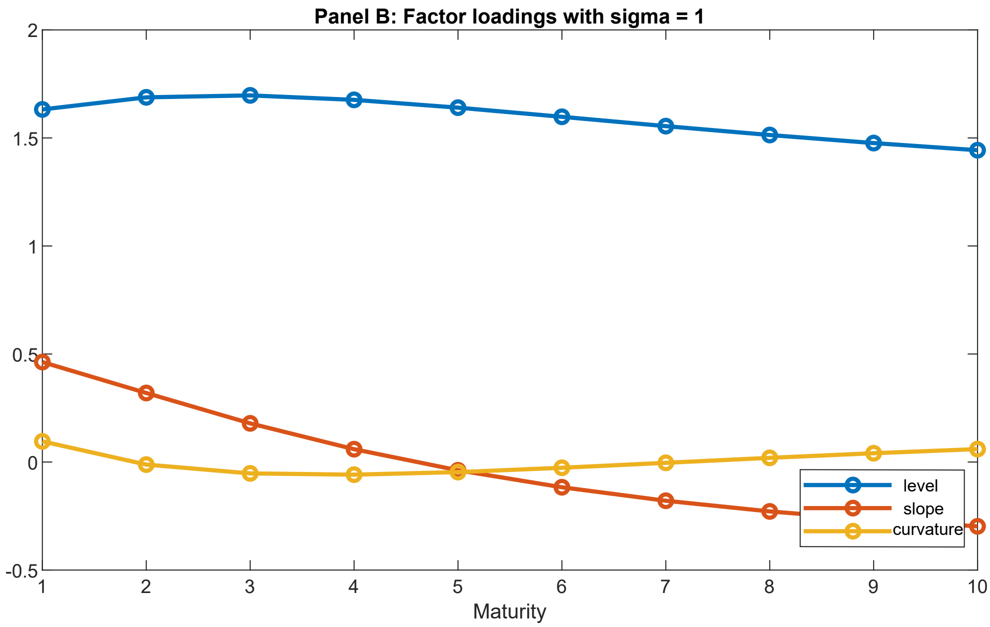


Fig. 8. Principal Component Loadings of the Yield Curve. This figure shows the loadings of the first three principal components for the non-normalized variance (top chart) and normalized variance (bottom chart) cases. The principal component analysis used the zero-coupon yields of maturities from 1 to 10 years. Sample period: January 1, 1999 to April 10, 2018. Frequency: Daily.

obvious from Panel A, the 5-year premium varies between negative 8 basis points and positive 6 basis points, but most of the time it does not exceed 3 to 4 basis points (in the absolute value). The order of the magnitude of the 5-year on-the-run premium broadly corresponds to the fitting error magnitude of that same maturity (see the top-right panel of Fig. 4). During the GFC, the premium briefly reached 6 to 7 basis points; however, during the European sovereign debt

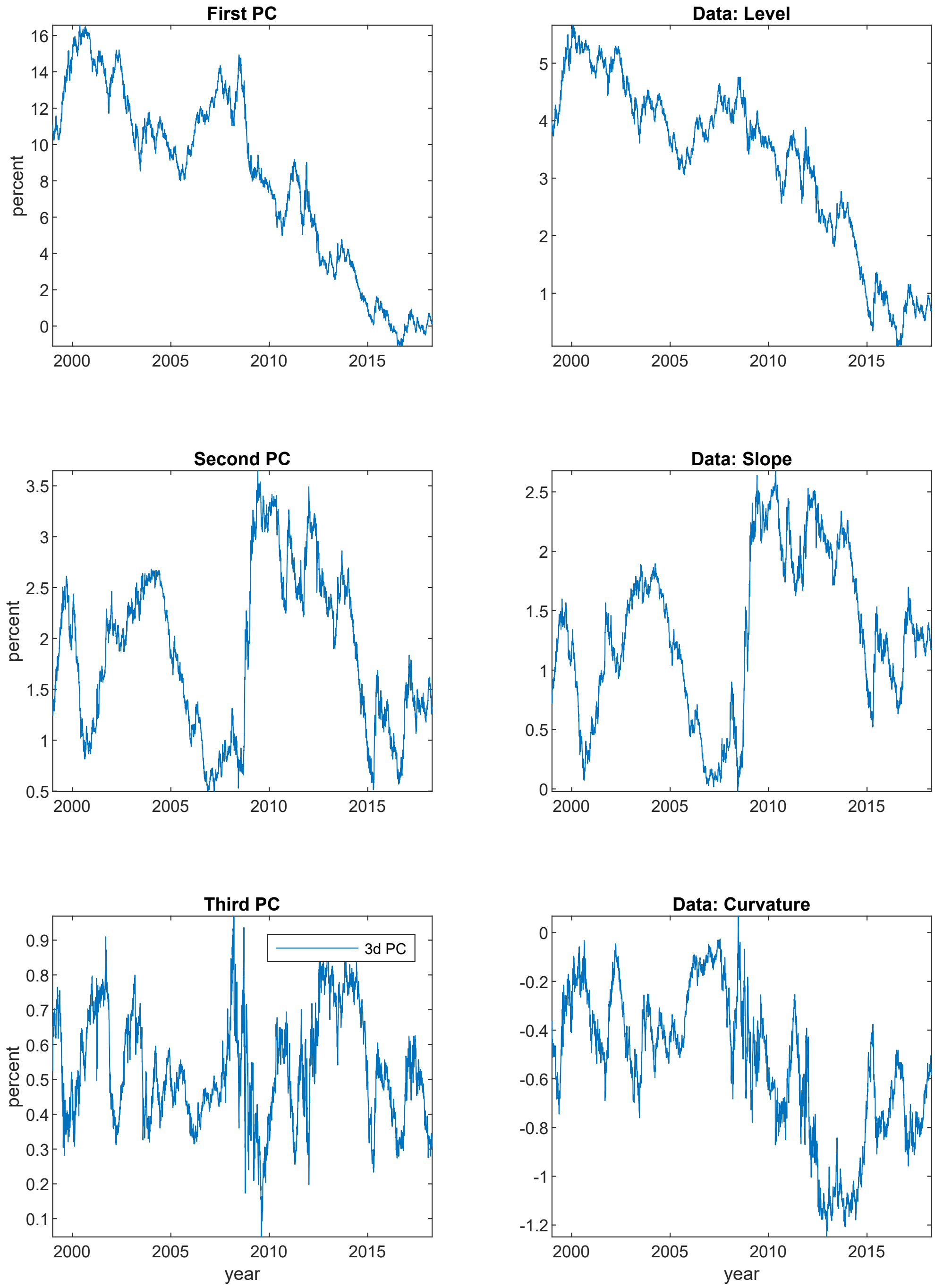


Fig. 9. Principal Components of the Yield Curve. This figure shows the time series of the first three principal components on the left-hand side; and the time-series for the level, slope, and curvature computed using fitted zero-coupon yields, on the right-hand side. For the level, we show the 10-year zero-coupon yield, for the slope, we show the difference between 10- and 2-year zero-coupon yields, and for the curvature, we show twice the 5-year yield minus the sum of the 2- and 10-year zero-coupon yields. Sample period is from January 1, 1999 to April 10, 2018. Frequency: daily.

crisis the premium appeared to be even slightly negative. As Panel B shows, the 10-year on-the-run premium has also been hovering within the 5 basis points band, reached briefly 15 basis points at the time of the GFC and declined following the global economic recovery.

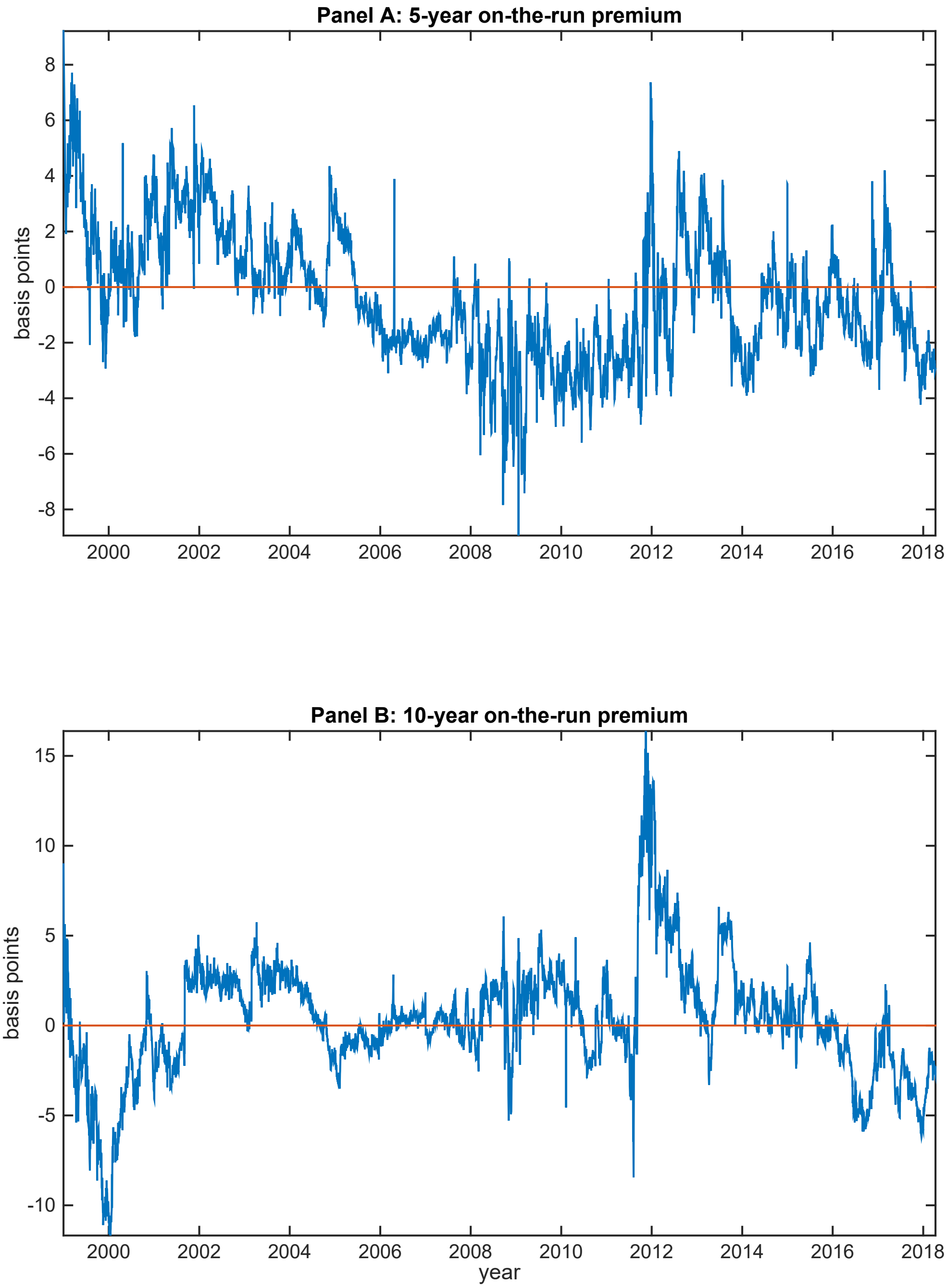


Fig. 10. GSW On-the-run Premium. This figure shows the time series of the 5-year (Panel A) and 10-year (Panel B) on-the-run premiums of the BTAN and OAT securities, respectively, following GSW methodology using synthetic bond. Sample period: January 1, 1999 to April 10, 2018. Frequency: daily.

Our findings are in contrast to the earlier findings in the relevant literature about the on-the-run premium in the U.S. nominal Treasury securities, which documented superior liquidity of on-the-run securities and the associated lower transaction costs. For example, ref.[4] report a ten times higher trading volume for on-the-run bonds and a collapse of the market share when on-the-run bonds go off the run (see Table 1 and in Figs. 1 and 2 in their paper). Fleming[15] reports that bid-ask spreads for on-the-run Treasury bills are five times smaller than for the off-the-runs (see his Table 1A). Finally, GSW also report that the U.S. on-the-run premium was as high as 30 to 40 basis points during several periods—for example, in the early 2000s—but appeared to have declined toward the end of its sample in 2006 to about 10 basis points. A number of potential channels potentially explain the on-the-run premium in the US nominal Treasury securities: a notorious relative scarcity of seasoned bond securities on the secondary markets; possible differential in tax treatments discussed (ref.[24,16]); larger specialness of on-the-run securities on the repo market (ref.[10,23]); search-based costs and externalities (Vayanos[35]); and, finally, demand for hedging interest rate risk (Graveline et al[18]).

It appears, though, that the French OAT market, as many other European sovereign debt markets function differently from the Treasuries market in the United States. Ejsing and Sihvonen[12] also document the non-existence of the on-the-run premium in the German Bund market. These authors relate it to unequal sizes of the cash and futures market in Germany and the set of deliverable bonds in the futures contracts. In France, there are a number of other factors that potentially explain our result:

1. **Debt issuance process in France.** In contrast to the United States, in France (as in many European countries), often an additional debt is not issued in the form of a new debt issue, but rather in the form of an additional bond amount added to an existing bond issue. In France, the first bond debt issue specifies what is called a *souche* (in French). The AFT can issue, at any time, new bonds of any existing *souche* and these newly issued bonds will have identical characteristics of the *souche.* In particular, they have the same maturity date meaning that their maturity equals to the remaining maturity of the primary bond, for example, 9.3 years. Newly issued bonds are fungible with existing ones meaning that there are no separate ISINs/CUSIPs for these issues and thus it is impossible to identify them separately. The time $t-$ outstanding amount of a given *souche* equals the whole amount of fungible bonds that have issued up to time t minus the amount of bonds that have been bought back, if any. The ability of the AFT to reopen at any time some debt issues is particularly useful and benefits the demand pressure of OAT/BTAN investors. All in all, this can address some liquidity issues and limit the potential scarcity of some specific bonds.
2. **French repo market.** The other difference is related to the structure of the repo market in France. French repo market has a reputation to be one of the largest markets in the world, and has two particular features that are worth mentioning:
   (a) **Regulated market-making process.** The primary and secondary French government debt markets rely on a network of primary dealers (called *Spécialistes en Valeurs du Trésor* (SVT) in French) whose mission is to maintain the liquidity on both markets. Since 2000, the French government debt can be transacted on electronic trading platforms. The SVT Market Committee currently selected two platforms, Brokertec Europe Ltd and MTS France, according to the European Primary Dealers Handbook of the ref.[1] Primary dealers are also registered as the market makers on the repo market.[24]
   (b) **Relationship between the Public Debt Fund and the repo market.** The Public Debt Fund (called *Caisse de la Dette Publique* (CDP) in French) has an influence on the repo market for the French government securities. The CDP is allowed (by using a repo facility) to lend to SVTs some French government securities that are difficult to obtain on the market in exchange for other French securities of the equivalent value. According to the European Primary Dealers Handbook of the AFME (2019/2020), "*SVTs may access a repo facility that provides temporary interest-bearing lending of the French Treasury securities (OATs and BTANs, including inflation-indexed securities) in exchange for other French Treasury securities of an equivalent value to the lent securities. Applications for the use of this facility are made to the AFT, which acts on behalf of CDP.*" This facility potentially limits the liquidity differential between recently issued and seasoned (and, supposedly, scarce) bonds. In addition, this should moderate the relative specialness of more recent debt securities. Actually, the French government provides securities to the CDP and, under the terms of the Budget Act, it may even issue some new securities for it. Potential implications of this particular feature of the French repo market remain largely unstudied and can be an interesting work on its own.[25]
3. **Tax treatment.** Currently, the tax treatment appears to be similar in the United States and in France, and, we conjecture, it may not be a potential explanation of the presence (in the US) and absence (in France) of the on-the-run premium. Relatedly, but slightly differently, Kamara[24] explains the tax premium by the differences between taxes on long-term capital gains, short-term capital gains, and ordinary income. However, the tax

[24] Also note that the French repo market has a variable interest rate repo.
[25] See the AFT website https://www.aft.gouv.fr/index.php/en/french-government-securities-repo-facility.

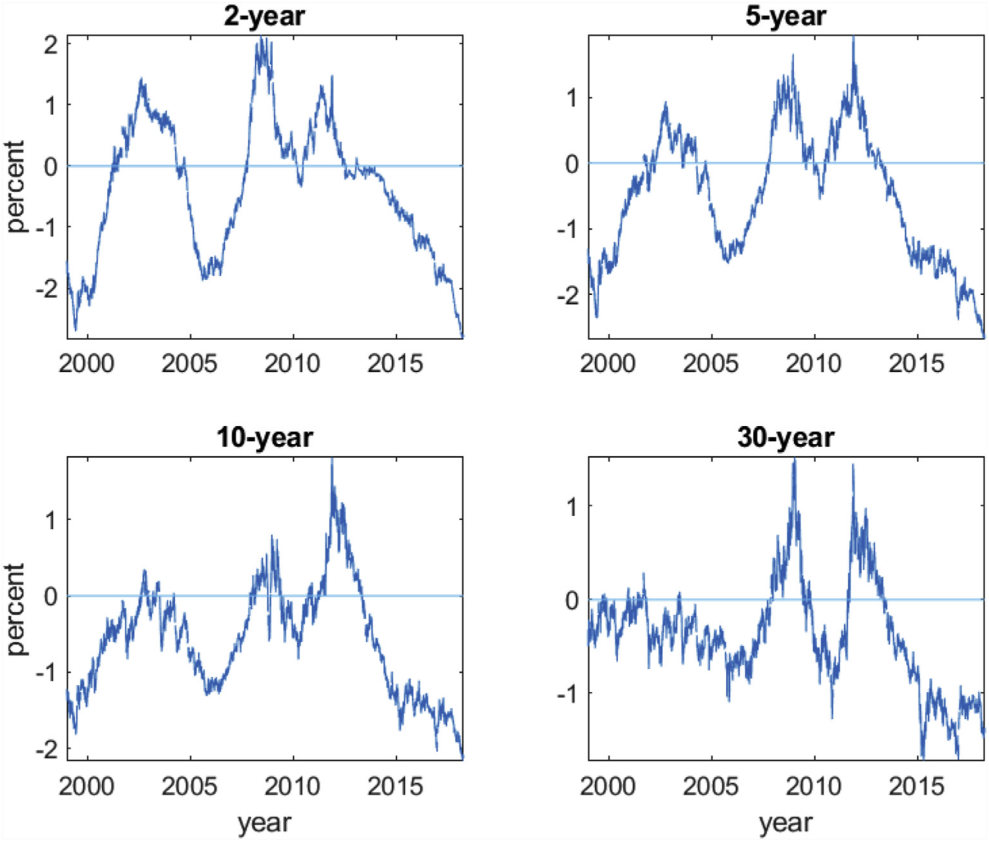


Fig. 11. US-OAT Sovereign Risk Spread. This figure shows the time series of the safety premium defined as OAT zero-coupon yields minus zero-coupon yields on the nominal US Treasury security of comparable maturities. Sample period: January 1, 1999 to April 10, 2018. Frequency: daily.

reform of 1986 in the United States changed some of the differential treatment of short-vs. long-term gains and interest vs capital gains. Supporting this view, Fontaine et al[16] argue that before 1986, interest income had a favorable tax treatment compared to capital gains, which led investors to favor high-coupon bonds. And in periods of rising interest rates, recently issued bonds with higher coupons were particularly more attractive than previously issued ones. Green[19] document that the high-coupon tax premium mostly disappeared following the 1986 tax reform in the United States. We provide more details about the French tax code in Appendix B.

4. **Futures market for OATs.** In 1986, the MATIF has proposed a futures contract, the *contrat notionnel* (in French). This futures contract was a very popular one, whose underlying was a fictitious French government OAT expiring in 10 years with the face value equal to FR 500,000.[26] The launch of Euro was fatal to the *contrat notionnel* that had to compete at that time with Bund futures contracts. The MATIF contract stopped trading on December 31, 1998. In 2012, Eurex exchanges decided to diversify the list of futures contracts written on European bonds and launched Euro-OAT futures contracts (FOATs) and mid-term Euro-OAT futures contracts (FOAMs). As shown by Ejsing and Sihvonen[12]; the existence of an active futures market as in Germany may lead to some special trading activities with respect to bonds that become deliverable and the resulting liquidity on the bond market would not restrain to the on-the-run securities.[27] They report that in the United States, the

[26] The MATIF was taken over by a series of mergers. First, it has been taken over by the SBF-Bourse Paris in 1998, before the launch of the SBF (that organized all regulated markets in Paris under its umbrella) in 1999. Next, the SBF merged with the Amsterdam Exchanges and with Brussels Exchanges to build the Euronext.

[27] A study of French futures contracts would be an interesting study on its own, which we leave for future research.

cash market is about twice as large as the futures market. So there is no possible squeeze of deliverable bonds and there is a marginal superior demand for only on-the-run securities.

Overall our findings of the negligible on-the-run premium motivate us to keep recently issued bonds in the cross section of OAT securities for our benchmark curve estimation.

7. A few other results about the French yield curve

7.1. OAT sovereign spreads

Fig. 11 shows the sovereign spread implied by the yields on OAT securities for 2-, 5-, 10, and 30-year maturities relative to the U.S nominal Treasury securities (US-OAT spread). We compute the sovereign spread as the difference of the OAT zero-coupon yields minus the zero-coupon yields on the nominal U.S. Treasury securities of comparable maturities. The latter yields are obtained from the smoothed off-the-run yield curve constructed by GSW. We obtained these from the Federal Reserve website.[28] The first conjecture is that since the US nominal Treasury securities are perceived by market participants as the safest assets globally, ceteris paribus, they are expected to have the lowest yields relative to other sovereign yields. The spread between the yield on a sovereign bond and the US Treasury yield would measure the degree to which this sovereign bond is perceived safe (or risky). Moreover, the variation in this

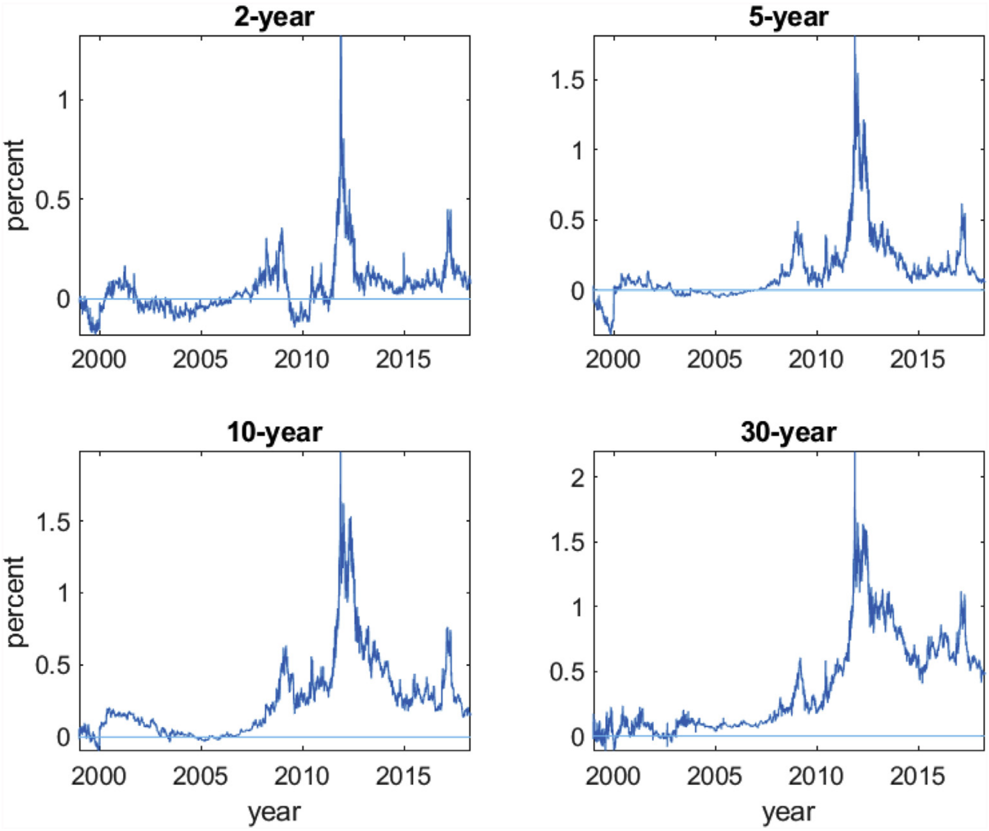


Fig. 12. Bund-OAT Sovereign Risk Spread. This figure shows the time series of the safety premium defined as OAT zero-coupon yields minus the zero-coupon yields on the nominal German securities of comparable maturities. Sample period: January 1, 1999 to April 10, 2018. Frequency: daily.

[28] See https://www.federalreserve.gov/data/nominal-yield-curve.htm.

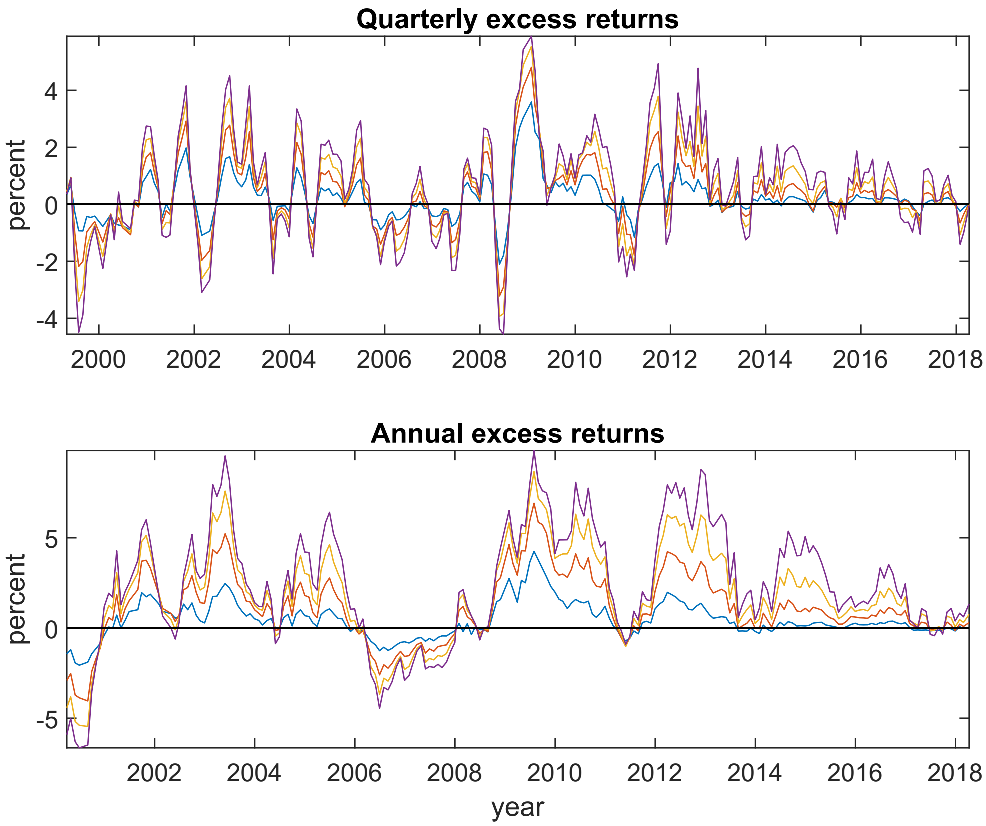


Fig. 13. OAT Excess Returns. This figure shows the time series of the OAT returns in excess of the 3-month French Treasury yields. Sample period: January 1, 1999 to April 10, 2018. Frequency: monthly.

spread, or, safety premium, would measure the change in countries' expected fundamentals relative to the US economy. We compute such spread for 2-, 5-, 10-, and 30-year yields. Fig. 11 shows the results. Interestingly, we find that such spread is not always positive. In particular, it became persistently negative in the last years of our sample.

The study of such variation in this spread is beyond the focus of this paper, and it can be an interesting study on its own. Potentially, negative and declining spreads at all maturities in the end of our sample can be attributed to at least two factors. The first one could be related to the asynchronous monetary policies in the US and globally. It is well known, that in the last few years the US was leading the easing monetary policy cycle in the world. As such, lately, monetary policy in the United States and elsewhere were divergent: when the Federal Reserve started easing, the ECB and other central banks were still tightening or keeping their policies on hold. Therefore, interest rates in the United States were lower in 2017−2018 relative to other advanced economies. The second explanation could be that there exists some local bias in the OAT market. Therefore, OAT investors may have traded OATs for reasons different from "chasing" the fundamentals. It is possible that the OAT clientele is separate from that who invests into the U.S. nominal Treasury securities, and that there are barriers between these two markets. Therefore, the OAT market may be functioning following its own set of influencing factors.

Fig. 12 shows the sovereign spread of OAT relative to German nominal Treasury securities, Bunds, (Bund-OAT spread). It is computed similarly to the US-OAT spread, except that we used zero-coupon Bund yields implied by the on-the-run yield curve that we downloaded from Bloomberg.[29] Because Germany has the largest economy in the euro

[29] There is no on-the-run premium for the Bund yields, Ejsing and Sihvonen[12] similarly to the OAT yields, therefore, on-the-run yield curve can be used in analysis. However, it is an imperfect proxy for the plethora of information contained in all traded bonds since it does not include off-the-run bonds.

Table 5
Predictability of OAT excess returns. The table reports the results of the predictive regressions of the OAT returns in excess of the 3-month French Treasury bills for quarterly and annual holding periods. CUSIP for this 3-month French government risk-free yield is GBTF3MO. Ref.[13,7] factors are used as predictors in these regressions. Sample period: January 1, 1999 to April 10, 2018. Frequency: monthly. Source: Bloomberg.

	Quarterly returns			Annual returns		
Panel A: 2-year OATs						
Const	−0.000	0.001	0.000	−0.000	0.004	−0.001
	(-0.01)	(1.57)	(0.35)	(-0.06)	(1.51)	(-0.41)
CP	0.506		0.147	0.318		−0.208
	(2.48)		(0.55)	(2.44)		(-0.45)
FS		0.385	0.336		0.359	0.407
		(2.28)	(1.14)		(1.04)	(2.14)
Adj. R2	5.18	4.87	4.88	5.97	2.04	5.87
Panel B: 3-year OATs						
Const	−0.000	0.001	−0.000	−0.000	0.006	−0.001
	(-0.07)	(0.66)	(-0.08)	(-0.03)	(1.16)	(-0.27)
CP	0.878		−0.024	0.792		−0.294
	(2.80)		(-0.07)	(3.05)		(-0.32)
FS		0.396	0.918		0.736	1.000
		(2.41)	(1.30)		(1.73)	(1.49)
Adj. R2	6.49	4.76	6.07	10.78	6.24	10.64
Panel C: 4-year OATs						
Const	−0.000	0.001	−0.000	−0.000	0.007	0.000
	(-0.01)	(0.23)	(-0.04)	(-0.00)	(0.85)	(0.01)
CP	1.180		0.045	1.245		0.093
	(2.94)		(0.12)	(3.38)		(0.11)
FS		0.423	1.090		0.983	1.167
		(2.39)	(1.21)		(2.06)	(1.47)
Adj. R2	6.75	4.92	6.34	13.92	9.42	13.54
Panel D: 5-year OATs						
Const	0.000	−0.000	−0.001	0.000	0.006	−0.001
	(0.06)	(-0.07)	(-0.17)	(0.04)	(0.57)	(-0.07)
CP	1.436		0.149	1.645		0.468
	(3.04)		(0.42)	(3.57)		(0.58)
FS		0.462	1.108		1.205	1.225
		(2.47)	(1.16)		(2.35)	(1.54)
Adj. R2	6.72	5.33	6.51	15.72	12.48	16.22

area and thus, perceived to be a leader in the European Union, it is a natural benchmark for assessing the sovereign risk in other euro-area countries. In contrast to the US-OAT spread, the OAT-Bund spread almost always positive. It is time-varying, spiked during the 2008 Global Financial Crisis, and consequently declined. Currently, the spread is positive: while it is close to zero for shorter maturities, it is between 20 and 50 basis points for 10- and 30-year horizons.

7.2. *Return predictability*

How predictable are OAT excess returns? This is a standard question in the literature about any bond market. To that end, we computed OAT quarterly and annual holding period returns. To compute quarterly excess returns, we subtracted the three-month French government risk-free yield from the quarterly holding period returns.[30] To compute annual excess returns, we subtracted one-year fitted zero-coupon yield that we obtained from our smoothed Svensson curve from annual holding period returns. Fig. 13 shows monthly series of quarterly and annual OAT excess returns for

[30] CUSIP for this yield is GBTF3MO, data is available from June 15, 1989. Source: Bloomberg. We have used the three-month French government risk-free rate instead of the three-month yield implied by the Svensson model. The reason is that Svensson model is notoriously known for its difficulty to fit the very short end of the curve, while being reasonably flexible to provide a realistic estimates of the medium-to long-horizon yields.

2-, 3-, 4- and 5-year maturities for the euro sample, from January 1, 1999 to April 2018. It is clear that there is a notable time variation in the OAT excess returns.

We have run predictability regressions using Fama and Bliss[13] (FS) maturity-specific forward spread factors and Cochrane and Piazzesi[7] (CP) factor that summarizes the information about term structure of forward rates in one factor. We run individual as well as joint regressions for 2-, 3-, 4-, and 5-year excess returns. Results are reported in Table 5. As the Table shows, predictability increases with the holding period horizon (quarterly or annual) and with the maturity of the bonds. The adjusted R^2 for quarterly excess returns varies between 5 and 7 percent roughly. The adjusted R^2 for annual excess returns varies between 2 and 16 percent and clearly increases with the maturity of the bond. This direction of results is in line with predictability reported for the U.S. Treasury securities. However, the magnitude of predictability is smaller. Adjusted R^2 for 5-year annual excess returns in our regressions is about 16 percent while CP report adjusted R^2 of 34 percent (See Table 1 in their paper). The difference may be due to a small sample issues— our sample twice as small as theirs: CP use 1964–2003 sample, we use 1999–2018 sample. The difference may also be due to a different economic environments that our samples cover. Thus, CP's sample does not have the 2008 Global Financial Crisis and the 2012–2013 Sovereign Bond Crisis in Europe. In contrast, our sample period does not contain, for example, the 1980s hyperinflation period and the 1990s Gulf war period. This may impact and explain differences in the magnitude of predictability. We leave further exploration of predictability of OAT excess returns for future research.

8. A closer look at the pre-euro era

In this section we report some results related to the period preceding the launch of the euro. We would like to emphasize some observable and significant differences between the periods preceding and following January 1, 1999. We examine the functioning/illiquidity of the French bond market through the lens of the noise measure introduced by HPW. Their proxy for illiquidity is defined as the root mean squared error between the market yields $\widehat{y}(t,i)$and model-implied yields $y_p(c, T_i; \widehat{\Theta}_t)$:

$$\text{Noise}_t = \sqrt{\frac{1}{N_t}\sum_{i=1}^{N_t}\left(\widehat{y}(t,i) - y^p(c, T_i; \widehat{\Theta}_t)\right)^2}, \tag{18}$$

where N_t is the number of considered bond securities on day t. The idea behind the *noise* measure (18) is that it indicates the availability of arbitrage capital on the bond market (or, on a different closely related market). When the arbitrage capital is abundant, arbitrage opportunities disappear quickly, so the prices converge quickly to the fundamentals, and observed prices are relatively close to the predicted prices estimated by the arbitrage-free model than in the periods when there is a shortage of such capital. Therefore, an increase in the noise measure indicates deterioration in market functioning conditions; conversely, a decrease reflects an improvement in market functioning conditions. This measure has been used widely by various researchers as a proxy for the liquidity measure in the U.S. Treasury securities market (see ref.[20,27,2]). Naturally, the noise measure (18) and the mean absolute error measure (15) are closely related.

8.1. Model fit

Similarly to Fig. 4, the Fig. 14 shows the MAEs (15) in the pre-euro period per maturity bins for our model (8). There are blank spaces in the period from 1988 to 1994 (for the 0–2 years range) and from 1988 to 1992 (for the 2–5 years range), as the OAT market was at its early stage of development. At that time, there were no OATs with remaining maturities of less than 5 years, and also there were no shorter-term OATs issued at that time. At that time, pricing errors were sometimes as high as 20 to 40 basis points depending on the maturity. In comparison, GSW report that the average absolute errors were quite high in their early part of their sample period, ranging from 40 to 80 basis points across different maturity ranges.

Similar to Section 5, we also demonstrate the model fit in the pre-euro area for several days. Fig. 15 shows the estimated Svensson nominal par yield curve on two different dates preceding the onset of the euro area —January 4, 1988 and September 20, 1995—and following the onset of the euro area, on January 5, 1999. The left-hand side of the figure shows the model-implied par yield curve along with observed (blue round circles) and predicted (red crosses)

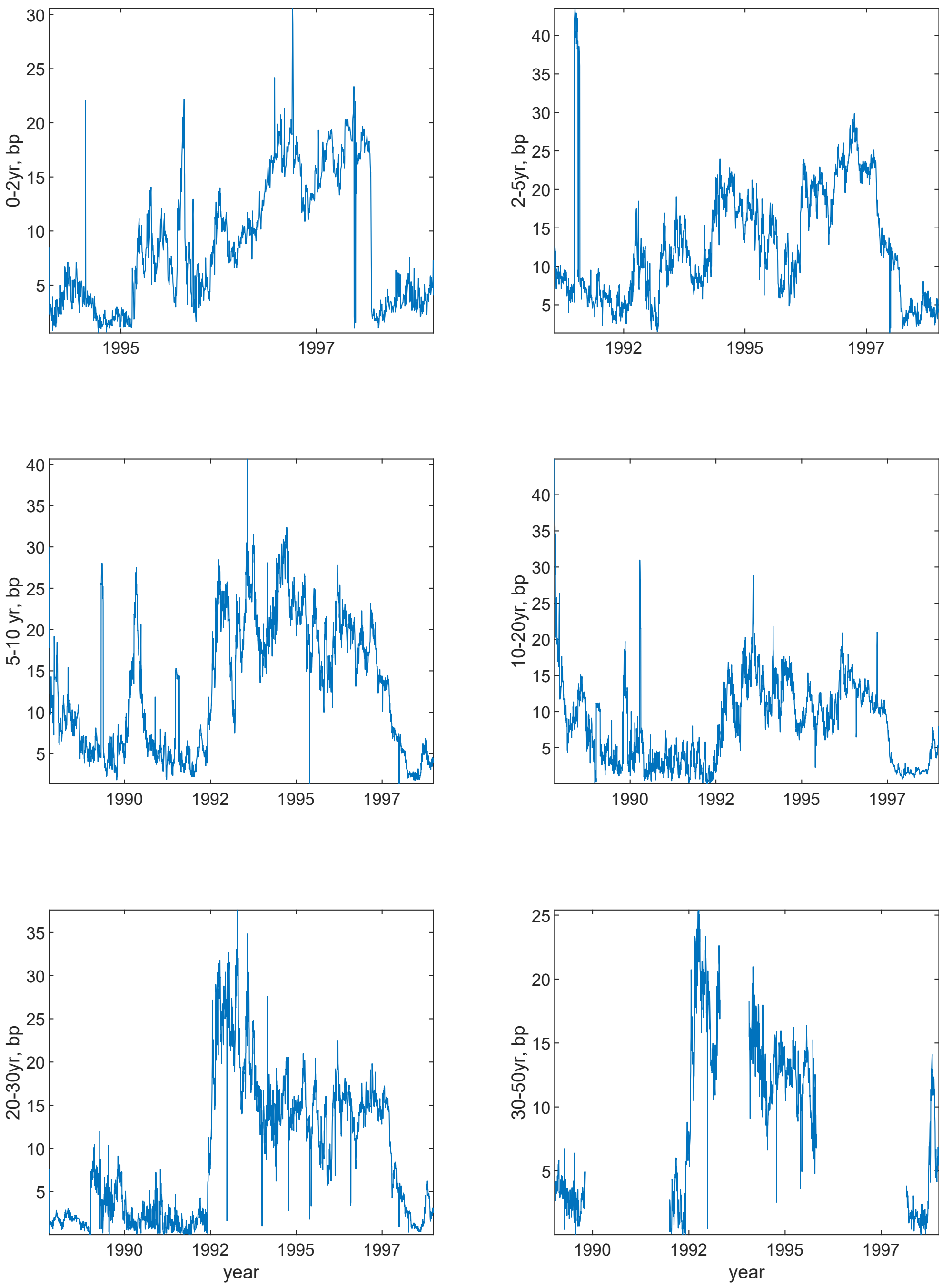


Fig. 14. Maturity-specific Fitting Errors: Pre-euro Sample. This figure shows the fitting errors of the Svensson[33] model implied by the BTANs and OATs computed as the mean absolute error between the predicted and the market prices in a certain maturity range. We report the errors for six maturity ranges: 0−2 years, 2−5 years, 5−10 years, 10−20 years, 20−30 years, and 30−50 years. The start of the sample in the charts depends on the selected maturity range. For all charts shown, the sample ends on December 30, 1998. He fitting errors are shown in basis points. Frequency: daily.

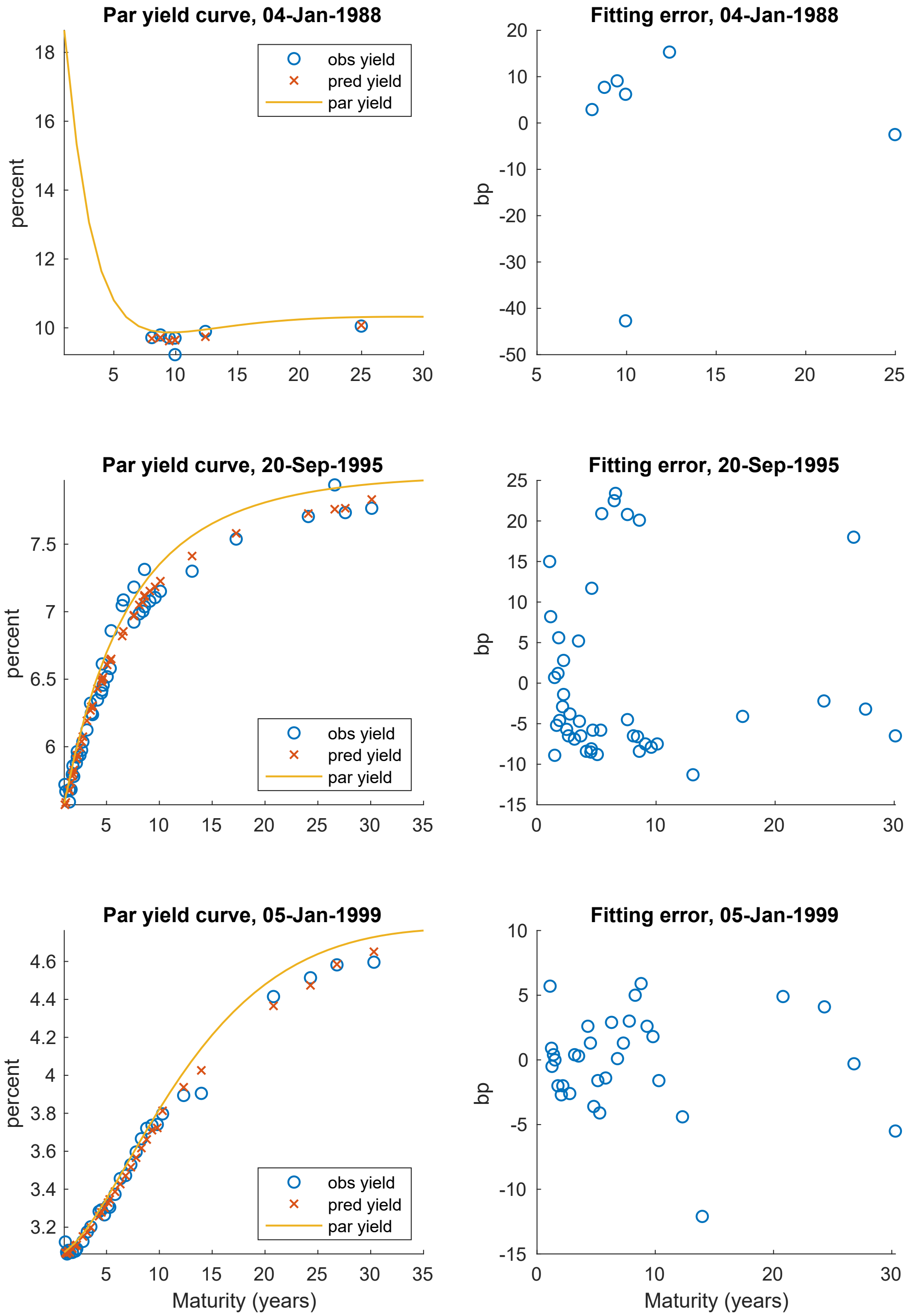


Fig. 15. Par Yield Curve: Pre-euro Sample Period. This figure shows the par yield curve and the fit of individual securities on the left-hand side and the security-specific fitting errors on the right-hand side in two days in the pre-euro-area period—January 4, 1988 and September 20, 1995—and a day following the onset of the euro area, January 5, 1999. The curve is reported in annualized percent, the fitting errors are reported in basis points.

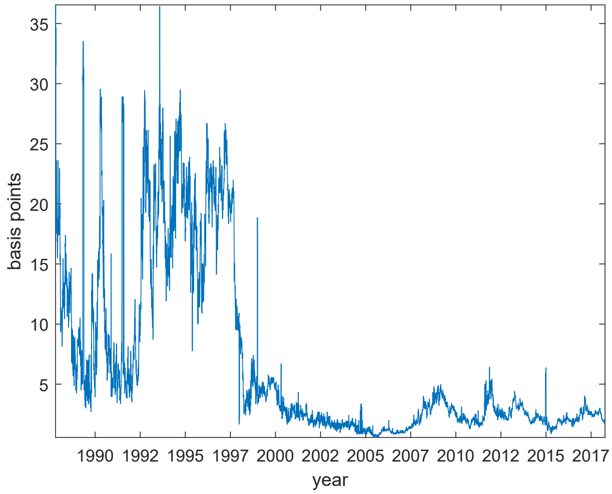


Fig. 16. Noise Measure of the French Bond Market. This figure shows the noise measure, which is computed as the root mean squared error between the observed and predicted yields across all available OAT/BTAN securities on a particular day. Frequency: daily. Sample period: October 22, 1987 to April 10, 2018.

yields on these three days. The predicted yields to maturity are computed by using parameters that are estimated on that day. The right-hand side of the figure shows security-specific pricing errors. The two upper graphs that are associated with January 4, 1988 highlight the fitting consequence of using only a few securities whose maturities are concentrated around the 10-year tenor. One of the securities appears to be especially poorly priced (with the pricing errors of negative 40 basis points).[31] With the exception of this security, the pricing errors ranged between zero and 10 basis points. We have refit the yield curve on January 4, 1988 by excluding this outlier. We find that the shape of the curve has not been materially impacted by the outlier.[32] This actually speaks in favor of using a very flexible Svensson parameterization that effectively smoothes through idiosyncratic variations in bond prices. In the paper, we decided to keep this outlier for our estimation for January 4, 1988, as we do not have specific filters for excluding particular potentially "incorrect" quotes. As the middle charts that correspond to September 20, 1995, show, in the mid 1990s the French market appeared to have been far more developed than in the late 1980s, as the number of available bond price quotes were larger and the maturity of these bonds was more diverse.[33] However, the range of pricing errors was, though smaller, still quite large, at between negative 10 to positive 15 basis points. Finally, the bottom charts present the yield curve and curve fit on January 5, 1999. Although the fitting errors still ranged from negative 10 to positive 15 basis points, it is interesting to observe the yield curve in the very beginning of the euro period.

8.2. *Noise measure*

We also assess and compare the quality of the functioning of the French market before and after the onset of the euro area using the noise measure (18). Fig. 16 demonstrates quantitatively how the market functioning improved after the launch of the euro. The noise measure fluctuated between 5 and 20 basis points before 1999 and reached 35 basis points at certain times in the pre-euro period. Upon the introduction of the euro, the noise measure plummeted almost instantaneously to levels around or below 5 basis points. Thus, the large "noise" values before 1999 can indicate mispricing and, therefore, the existence of arbitrage opportunities. The volatility of the noise measure can be indicative of some arbitrage activities. It is interesting to note that the noise measure never exceeded 35 basis points, suggesting that, in general, the fitting ability of the Svensson model is reasonable (as it was illustrated by the discussion of Fig. 15 in the previous subsection).

[31] Informal interviews of practitioners confirm that the arbitrage opportunities were not infrequent at that time.

[32] Results are not shown but available upon request. We thank an anonymous referee for raising the question about the influence of the presence of this outlier for the shape of the yield curve.

[33] We showed a usual day at that time period for the middle charts on Fig. 15.

9. Conclusion

Our study is the first comprehensive study of all publicly available data of the French nominal debt that encompasses the 30-year period from 1988 to 2018. In particular, we construct the French nominal yield curve using quotes of the OAT and BTAN French nominal government bond securities at a daily frequency. Our sample period starts in October 1987, and ends in April 2018. We use the Svensson[33] smoothing method to interpolate the curve. The fit of the curve is quite reasonable and especially improved after the launch of the euro area. We attribute a dramatic improvement in the fit of the OAT yield following the onset of the euro area to the influx of the european investors on the French sovereign debt market.

Overall, we find that in the first decade, the arbitrage opportunities were not infrequent on the OAT market, but that the situation improved substantially since the euro introduction. Since then, the market functioned reasonably well outside of a few episodes—notably, the Global Financial Crisis the European sovereign crisis periods. We also find that, in sharp contrast to the U.S. nominal Treasury securities market, the on-the-run premium is negligible on the French market. We attribute the absence of the on-the-run premium to a range of factors, mainly to a different debt issuance process in France, and a very active repo market for OATs. We show that, similar to other developed economies, French interest rates have been declining since the Global Financial Crisis, and that the slope of the French yield curve declined as well, potentially predictive of some increased downside risks to the growth of the French economy. We also document interesting results about the variation in OAT sovereign spreads. Finally, we find that, similarly to the U.S. market, French bond excess returns are predictable.

Our results and available yield curve data should be valuable to central bankers, monetary policy makers, as well as financial and macroeconomic researchers of European fixed income markets. We plan to update our results regularly.

Conflicts of interest

All authors have none to declare.

Appendix

A Summary of the nominal BTAN and OAT securities

Tables A1 through A5 present a summary of the nominal BTAN and OAT securities. For each security we list the type (OAT or BTAN), ISIN number, annual coupon rate, issue date, maturity date, the term of the security, the date on which the security had the first quote in Bloomberg, and the total number of observations for that security. Table A1 lists securities issued from 1984 through 1994; Table A2 — from 1995 through 2000; Table A3 — from 2001 through 2007; Table A4 — from 2008 through 2014; and Table A5 — from 2015 to 2018.

There is a peculiar security FR0000570244 in Table A1. The security was issued on January 26, 1987 and matured on November 25, 2002. However, Bloomberg has only 97 quotes for it in the last year of its life, from March 25, 2002 to November 25, 2002. Therefore, we do not use this security's quotes in our estimation because we eliminate all securities less than 12 month of remaining maturity (see our filter 3 in Section 4.3). However, we accounted for this security in Fig. 2 and therefore, we included it in Table A1.

B Taxation in France

The current tax code in France helps explaining number of peculiarities on French OAT market. The 2017 tax reform in France (Article 28 of Act 2017−1837 of December 30, 2017) has altered the traditional taxation of capital gains and investment income.[34] Currently, the tax treatment of capital gains appears to be similar in the United States and in France. With respect to the US evidence, Kamara[24] finds out that there is a tax premium between the short-term and long-term securities. He explains the tax premium by the differences between taxes on long-term capital gains, short-term capital gains, and ordinary income. However, the tax reform of 1986 in the United States changed some of

[34] See the AFT website https://www.aft.gouv.fr/index.php/en/tax-treatment-securities.

the tax laws related to the capital gains. Supporting this view, Fontaine et al[16] argue that before 1986, interest income had a favorable tax treatment compared to capital gains, which led investors to favor high-coupon bonds. And in periods of rising interest rates, recently issued bonds with higher coupons were particularly more attractive than previously issued ones. Green et al[19] document that the high-coupon tax premium mostly disappeared following the 1986 tax reform in the United States.

Since January 1, 2018, for individual French residents, capital gains and investment income became automatically subject to personal income tax at a flat rate of 12.8 percent under the terms of Article 200 A (1) of the General Tax Code (CGI), in addition to social security contributions at an aggregate rate of 17.2 percent bringing up the total tax rate to 30 percent. The taxpayer has, however, the option to have these gains and income taxed at the rate corresponding to their personal income tax bracket. This irrevocable option applies to all such gains and income and must be chosen when declaring an aggregate income. These laws imply different treatments with regard to households, non-profit organizations, legal entities, institutional investors, and non-residents, that we briefly summarize below.[35]

- **Modest income households.** Some exemptions to taxation currently exist for modest income households. Current taxation rules make implicitly their best to attract modest income households as investors by such exemptions.
- **Non-profit organizations.** For non-profit organizations, a distinction is made between organizations that engage in profit-making businesses and those that do not. When the income comes from the non-profit business activity of the non-profit organization, income from government bonds issued after 1 January 1987 is subject to a 10 percent corporate income tax rate. Capital gains on sales are not subject to corporate income tax. When the income comes from the profit-making business activity of the non-profit organization or when the non-profit organization is subject to corporate income tax for all of its activities, the income is taxed in accordance with the rules set forth for entities subject to corporate income tax.
- **Legal entities.** For legal entities subject to corporate income tax, all of the earnings included in taxable income (interest, redemption premiums and capital gains booked on sales of securities) are subject to corporate income tax at the standard rate of 33 1/3 percent or 28 percent for the first € 500,000 in profits for each 12-month period for financial years, plus the 3.3 percent social contribution on profits, where applicable. The standard corporate income tax rate has been lowered to 31 percent as of January 1, 2019 for all profits after the first € 500,000. It has been lowered for all profits to 28 percent as of January 1, 2020. It will be gradually lowered to 26.5 percent as of January 1, 2021 and to 25 percent as of January 1, 2022. Interest earned on French Treasury bonds is taxable on an accrual basis rather than in arrears. A tax rule stipulates the taxation of securities with redemption premiums according to an actuarial apportionment formula, if the average price at issue is less than 90 percent of the redemption value, meaning that the premium is more than 10 percent of the purchase price of the security in question. In such cases, the redemption premium and the interest paid annually are taxed each year on the basis of an apportionment by actuarial calculation over the residual maturity of the security or contract at the purchase date.
- **Institutional investors.** For institutional investors (such as credit institutions, finance companies and investment companies) that buy and hold fixed-income securities in an investment securities account or buy investment securities for a price that is different from the redemption price, the gain or loss arising from the difference between the purchase price of the securities and the redemption price, plus or minus accrued interest at the time of purchase, is apportioned over the residual maturity of the security on the basis of an actuarial calculation.
- **Insurance companies.** For insurance and accumulation companies buy bonds other than inflation-linked bonds at a price that is different from the redemption price, the loss or gain from this difference is spread over the residual maturity for the purposes of calculating the entity's taxable income. When several redemption dates are scheduled, the longest date is used. This apportionment is determined on the basis of an actuarial calculation.

[35] The AFT website https://www.aft.gouv.fr/index.php/en/tax-treatment-securities as well as https://www.aft.gouv.fr/en/tax-treatment-securities provide more details. Interested readers may also consult the “Article 125 A″ of the “Code Général des Impôts”. One can also see https://www.legifrance.gouv.fr/that gives the long list of modifications that intervene during the period of our dataset.

- **Non-residents.** For non-residents, interest, annuities and all other income from bonds, government securities and all other negotiable debt securities issued by the government and held by non-residents are not subject to withholding taxes, in accordance with Article 132 a (for securities issued before 1 January 1987) and Article 119 a (1.) of the General Tax Code (for securities issued on or after 1 January 1987). In a number of cases, France has some international tax treaties.

Table A1
Summary of the Nominal BTAN and OAT Securities, issues 1984−1994. This table shows the sample of the nominal BTAN and OAT securities issued from 1984 to 1994. Column "Type" refers to the type of the security (BTAN or OAT), "ISIN" — to the ISIN number, "Coupon" — the coupon rate in percent,"First quote" — the first available quote date, "Maturity date" — the expiration date, "Term" — the term-to-maturity, "N obs." — the number of available daily observations for the security. Dates are in the mm/dd/yyyy format. Source: Bloomberg.

Type	ISIN	Coupon	Issue date	Maturity date	Term	First quote	N obs.
OAT	FR0000041410	11.6	10/8/1984	10/8/1996	12.00	7/1/1987	1313
OAT	FR0000570095	10	6/14/1985	5/27/2000	14.95	7/1/1987	2772
OAT	FR0000043705	9.9	12/13/1985	12/13/1997	12.00	7/1/1987	2614
OAT	FR0000100257	9.8	1/30/1986	1/30/1996	10.00	7/1/1987	2203
OAT	FR0000100240	9.7	1/30/1986	12/13/1997	11.87	7/1/1987	2637
OAT	FR0000570178	7.5	8/25/1986	7/25/2001	14.92	7/31/1989	1876
OAT	FR0000570244	8	1/26/1987	11/25/2002	15.83	3/25/2002	97
OAT	FR0000570780	8.5	2/25/1987	12/26/2012	25.83	7/1/1987	6587
OAT	FR0000102469	8.5	3/25/1987	6/25/1997	10.25	7/1/1987	2570
OAT	FR0000570921	8.5	1/25/1989	10/25/2019	30.75	1/6/1989	7862
OAT	FR0000570327	8.25	2/27/1989	2/27/2004	15.00	7/1/1988	3900
OAT	FR0000570038	8.125	12/26/1989	5/25/1999	9.41	1/6/1989	2689
OAT	FR0000570053	8.5	1/1/1990	3/28/2000	10.24	1/4/1990	2659
OAT	FR0000570152	10	11/1/1990	2/26/2001	10.32	11/6/1990	2180
OAT	FR0000570145	9.5	1/1/1991	1/25/2001	10.07	1/3/1991	2619
OAT	FR0000570194	8.5	5/1/1991	3/15/2002	10.87	4/24/1991	2349
OAT	FR0000570061	9.5	6/1/1991	4/25/2000	8.90	4/12/1990	2264
BTAN	XB000A112181	9	7/12/1991	2/12/1996	4.59	1/8/1991	1325
OAT	FR0000571085	8.5	1/1/1992	4/25/2023	31.31	12/31/1991	6851
BTAN	XB000A112413	8.5	1/13/1992	11/12/1996	4.83	7/19/1991	1384
OAT	FR0000571044	8.25	2/1/1992	4/25/2022	30.23	1/22/1992	6569
OAT	FR0000114308	8.5	3/1/1992	5/12/1997	5.20	4/27/1989	2087
OAT	FR0000570665	8.5	6/1/1992	10/25/2008	16.40	6/2/1992	4278
BTAN	XB000A112728	8.5	7/10/1992	3/12/1997	4.67	1/13/1992	1345
OAT	FR0000110488	9.5	7/20/1992	6/25/1998	5.93	3/3/1988	2664
OAT	FR0000570277	8.5	7/20/1992	4/25/2003	10.76	6/24/1992	2827
OAT	FR0000570285	8	7/27/1992	4/25/2003	10.74	2/3/1993	1688
BTAN	XB000A113007	8.5	1/12/1993	11/12/1997	4.83	7/8/1992	1391
OAT	FR0000570301	6.75	4/26/1993	10/25/2003	10.50	1/3/2000	992
BTAN	XB000A113270	8	7/12/1993	5/12/1998	4.83	12/31/1992	1394
OAT	FR0000194995	6	7/16/1993	7/16/1997	4.00	6/25/1993	550
OAT	FR0000570343	6	10/11/1993	4/25/2004	10.54	1/3/2000	894
OAT	FR0000570368	5.5	11/25/1993	4/25/2004	10.41	1/3/2000	1124
BTAN	XB000A113528	5.75	1/12/1994	11/12/1998	4.83	6/25/1993	1383
BTAN	FR0100059486	4.75	2/14/1994	4/12/1999	5.16	1/4/1994	1372
OAT	FR0000571150	6	2/25/1994	10/25/2025	31.66	1/24/1994	6312
OAT	FR0000570228	6.75	5/25/1994	4/25/2002	7.92	4/29/1994	1564
OAT	FR0000570400	6.75	6/27/1994	10/25/2004	10.33	1/3/2000	1255
BTAN	XB000A113817	4.5	7/5/1994	5/12/1996	1.85	1/4/1994	614
OAT	FR0000570434	7.5	10/25/1994	4/25/2005	10.50	1/3/2000	1385

Table A2
Summary of the Nominal BTAN and OAT Securities, issues 1995–2000. This table shows the sample of the nominal BTAN and OAT securities issued from 1995 to 2000. Column “Type” refers to the type of the security (BTAN or OAT), “ISIN” — to the ISIN number, “Coupon” — the coupon rate in percent,“First quote” — the first available quote date, “Maturity date” — the expiration date, “Term” — the term-to-maturity, “N obs.” — the number of available daily observations for the security. Dates are in the mm/dd/yyyy format. Source: Bloomberg.

Type	ISIN	Coupon	Issue date	Maturity date	Term	First quote	N obs.
BTAN	FR0100059502	7	1/12/1995	11/12/1999	4.83	7/6/1994	1397
BTAN	XB000A114096	6.5	3/6/1995	10/12/1996	1.60	7/6/1994	593
OAT	FR0000570467	7.75	4/25/1995	10/25/2005	10.50	1/3/2000	1516
BTAN	FR0100059528	7.75	7/12/1995	4/12/2000	4.75	1/6/1995	1374
BTAN	FR0100059544	7	8/11/1995	10/12/2000	5.17	7/11/1995	1371
BTAN	XB000A113346	7.25	9/27/1995	3/16/1998	2.47	2/24/1993	1312
OAT	FR0000570491	7.25	10/25/1995	4/25/2006	10.50	1/3/2000	1646
BTAN	XB000A114476	7.25	11/6/1995	8/12/1997	1.77	3/7/1995	634
BTAN	XB000A114468	7.5	11/22/1995	3/16/1997	1.31	2/23/1995	536
OAT	FR0000570731	6.5	2/26/1996	4/25/2011	15.16	1/3/2000	2950
OAT	FR0000570533	6.5	4/25/1996	10/25/2006	10.50	1/3/2000	1776
OAT	FR0000570509	7	5/23/1996	4/25/2006	9.92	1/3/2000	1281
BTAN	FR0100000365	5.75	6/5/1996	3/12/1998	1.77	11/10/1995	606
BTAN	FR0100059551	5.75	6/12/1996	3/12/2001	4.75	1/8/1996	1350
BTAN	FR0100059577	5.5	8/12/1996	10/12/2001	5.17	7/8/1996	1373
BTAN	FR0100059478	5	9/26/1996	3/16/1999	2.47	1/10/1994	1304
BTAN	FR0100059569	6	12/27/1996	3/16/2001	4.22	1/9/1996	1130
BTAN	FR0100024795	4.5	1/6/1997	10/12/1998	1.76	6/18/1996	596
OAT	FR0000570574	5.5	1/23/1997	4/25/2007	10.25	1/3/2000	1906
BTAN	FR0100059585	4.75	3/12/1997	3/12/2002	5.00	1/24/1997	1317
OAT	FR0000570590	5.5	7/10/1997	10/25/2007	10.29	1/3/2000	2037
BTAN	FR0100059593	4.5	7/24/1997	7/12/2002	4.97	7/16/1997	1303
BTAN	FR0100015967	4.5	7/24/1997	7/12/2002	4.97	7/15/1997	381
OAT	FR0000570632	5.25	1/15/1998	4/25/2008	10.28	1/3/2000	2168
BTAN	FR0100059601	4.5	2/26/1998	7/12/2003	5.37	2/23/1998	1405
OAT	FR0000571218	5.5	3/12/1998	4/25/2029	31.12	2/26/1998	5245
BTAN	FR0100059510	4	3/26/1998	1/12/2000	1.80	9/18/1997	603
BTAN	FR0100059536	4	5/28/1998	7/12/2000	2.12	5/20/1998	560
OAT	FR0000571432	4	10/8/1998	4/25/2009	10.55	10/1/1998	2755
BTAN	FR0100034208	4	12/24/1998	7/12/2000	1.55	4/8/1998	191
BTAN	FR0100033242	4.5	12/24/1998	7/12/2003	4.55	2/24/1998	223
BTAN	FR0100802273	3.5	1/28/1999	7/12/2004	5.45	1/21/1999	1429
BTAN	FR0100877812	3	3/25/1999	7/12/2001	2.30	3/18/1999	606
OAT	FR0000186199	4	5/12/1999	10/25/2009	10.46	1/3/2000	2559
BTAN	FR0101465831	4	10/28/1999	1/12/2002	2.21	10/20/1999	576
BTAN	FR0101659813	5	1/27/2000	7/12/2005	5.46	1/19/2000	1431
OAT	FR0000186603	5.5	2/8/2000	4/25/2010	10.21	1/27/2000	2671
BTAN	FR0102325695	5	8/17/2000	1/12/2003	2.40	8/17/2000	627
OAT	FR0000187023	5.5	9/12/2000	10/25/2010	10.12	9/7/2000	2641
BTAN	FR0102626779	5	10/24/2000	1/12/2006	5.22	10/18/2000	1368

Table A3
Summary of the Nominal BTAN and OAT Securities, 2001–2007. This table shows the sample of the nominal BTAN and OAT securities issued from 2001 to 2007. Column “Type” refers to the type of the security (BTAN or OAT), “ISIN” — to the ISIN number, “Coupon” — the coupon rate in percent,“First quote” — the first available quote date, “Maturity date” — the expiration date, “Term” — the term-to-maturity, “N obs.” — the number of available daily observations for the security. Dates are in the mm/dd/yyyy format. Source: Bloomberg.

Type	ISIN	Coupon	Issue date	Maturity date	Term	First quote	N obs.
OAT	FR0000187361	5	2/6/2001	10/25/2016	15.72	1/16/2001	4112
BTAN	FR0103230423	4.5	4/24/2001	7/12/2006	5.22	4/20/2001	1363
OAT	FR0000187635	5.75	6/12/2001	10/25/2032	31.37	6/7/2001	4391
OAT	FR0000187874	5	9/11/2001	10/25/2011	10.12	9/6/2001	2640
BTAN	FR0103536092	4	9/25/2001	1/12/2004	2.30	9/17/2001	605

Table A3 (*continued*)

Type	ISIN	Coupon	Issue date	Maturity date	Term	First quote	N obs.
BTAN	FR0103840098	3.75	11/27/2001	1/12/2007	5.13	11/20/2001	1342
OAT	FR0000188328	5	3/12/2002	4/25/2012	10.12	3/1/2002	2647
BTAN	FR0104446556	4.75	5/16/2002	7/12/2007	5.16	5/13/2002	1348
OAT	FR0000188690	4.75	9/10/2002	10/25/2012	10.12	9/2/2002	2647
BTAN	FR0104756962	3.5	9/24/2002	1/12/2005	2.30	9/12/2002	610
BTAN	FR0105427795	3.5	1/28/2003	1/12/2008	4.96	1/15/2003	1303
OAT	FR0000188989	4	3/11/2003	4/25/2013	10.12	2/28/2003	2648
OAT	FR0000189151	4.25	6/10/2003	4/25/2019	15.87	6/2/2003	3876
BTAN	FR0105760112	3	6/24/2003	7/12/2008	5.05	6/16/2003	1325
OAT	FR0010011130	4	9/9/2003	10/25/2013	10.13	8/27/2003	2651
BTAN	FR0106589437	3.5	1/22/2004	1/12/2009	4.97	1/16/2004	1301
OAT	FR0010061242	4	3/9/2004	4/25/2014	10.13	2/24/2004	2652
BTAN	FR0106589445	2.25	3/23/2004	3/12/2006	1.97	3/12/2004	521
OAT	FR0010070060	4.75	4/6/2004	4/25/2035	31.05	3/23/2004	3660
BTAN	FR0106841887	3.5	6/22/2004	7/12/2009	5.05	6/11/2004	1326
OAT	FR0010112052	4	9/7/2004	10/25/2014	10.13	8/26/2004	2650
BTAN	FR0107369672	3	11/23/2004	1/12/2010	5.14	11/17/2004	1344
OAT	FR0010163543	3.5	2/8/2005	4/25/2015	10.21	2/1/2005	2667
BTAN	FR0107489959	2.25	2/22/2005	3/12/2007	2.05	2/15/2005	539
OAT	FR0010171975	4	2/28/2005	4/25/2055	50.15	2/24/2005	3421
OAT	FR0010192997	3.75	5/10/2005	4/25/2021	15.96	5/3/2005	3375
BTAN	FR0107674006	2.5	6/21/2005	7/12/2010	5.06	6/14/2005	1324
OAT	FR0010216481	3	7/12/2005	10/25/2015	10.29	7/7/2005	2685
BTAN	FR0108197569	2.75	11/22/2005	3/12/2008	2.30	11/17/2005	604
BTAN	FR0108354806	3	1/24/2006	1/12/2011	4.97	1/17/2006	1301
OAT	FR0010288357	3.25	2/7/2006	4/25/2016	10.21	1/30/2006	2665
BTAN	FR0108847049	3.5	6/20/2006	7/12/2011	5.06	6/9/2006	1328
BTAN	FR0109136137	3.5	7/25/2006	9/12/2008	2.14	7/19/2006	562
OAT	FR0010371401	4	9/12/2006	10/25/2038	32.12	8/30/2006	3029
OAT	FR0010415331	3.75	1/9/2007	4/25/2017	10.29	12/29/2006	2688
BTAN	FR0109970386	3.75	1/23/2007	1/12/2012	4.97	1/15/2007	1305
BTAN	FR0110979178	4	4/24/2007	9/12/2009	2.39	4/17/2007	629
OAT	FR0010466938	4.25	5/9/2007	10/25/2023	16.46	4/30/2007	2856
BTAN	FR0110979186	4.5	6/26/2007	7/12/2012	5.05	6/18/2007	1324
OAT	FR0010517417	4.25	9/11/2007	10/25/2017	10.12	9/3/2007	2645

Table A4

Summary of the Nominal BTAN and OAT Securities, 2008−2014. This table shows the sample of the nominal BTAN and OAT securities issued from 2008 to 2014. Column "Type" refers to the type of the security (BTAN or OAT), "ISIN" — to the ISIN number, "Coupon" — the coupon rate in percent,"First quote" — the first available quote date, "Maturity date" — the expiration date, "Term" — the term-to-maturity, "N obs." — the number of available daily observations for the security. Dates are in the mm/dd/yyyy format. Source: Bloomberg.

Type	ISIN	Coupon	Issue date	Maturity date	Term	First quote	N obs.
BTAN	FR0113087466	3.75	1/22/2008	1/12/2013	4.97	1/14/2008	1304
OAT	FR0010604983	4	4/8/2008	4/25/2018	10.05	4/1/2008	2615
BTAN	FR0113872776	3.75	5/20/2008	9/12/2010	2.31	5/12/2008	610
BTAN	FR0114683842	4.5	7/22/2008	7/12/2013	4.97	7/15/2008	1303
OAT	FR0010670737	4.25	10/7/2008	10/25/2018	10.05	10/1/2008	2484
BTAN	FR0116114978	2.5	1/27/2009	1/12/2014	4.96	1/20/2009	1298
BTAN	FR0116843519	1.5	5/26/2009	9/12/2011	2.30	5/18/2009	608
BTAN	FR0116843535	3	6/23/2009	7/12/2014	5.05	6/17/2009	1323
OAT	FR0010773192	4.5	6/30/2009	4/25/2041	31.82	6/23/2009	2295
OAT	FR0010776161	3.75	7/7/2009	10/25/2019	10.30	6/30/2009	2290
BTAN	FR0117836652	2.5	1/26/2010	1/15/2015	4.97	1/19/2010	1302
OAT	FR0010854182	3.5	2/9/2010	4/25/2020	10.21	2/2/2010	2133
OAT	FR0010870956	4	3/17/2010	4/25/2060	50.11	3/11/2010	2105

(*continued on next page*)

Table A4 (*continued*)

Type	ISIN	Coupon	Issue date	Maturity date	Term	First quote	N obs.
BTAN	FR0118153370	0.75	5/25/2010	9/20/2012	2.32	5/18/2010	612
BTAN	FR0118462128	2	6/22/2010	7/12/2015	5.05	6/15/2010	1323
OAT	FR0010916924	3.5	7/6/2010	4/25/2026	15.80	6/28/2010	2031
OAT	FR0010949651	2.5	10/12/2010	10/25/2020	10.04	10/5/2010	1960
BTAN	FR0119105809	2.25	1/25/2011	2/25/2016	5.08	1/18/2011	1328
BTAN	FR0119580019	2	5/24/2011	9/25/2013	2.34	5/18/2011	615
OAT	FR0011059088	3.25	6/7/2011	10/25/2021	10.38	5/31/2011	1790
BTAN	FR0119580050	2.5	6/21/2011	7/25/2016	5.10	6/14/2011	1331
OAT	FR0011196856	3	2/7/2012	4/25/2022	10.21	1/31/2012	1615
BTAN	FR0120473253	1.75	2/21/2012	2/25/2017	5.01	2/15/2012	1310
BTAN	FR0120634490	0.75	4/24/2012	9/25/2014	2.42	4/17/2012	637
BTAN	FR0120746609	1	7/24/2012	7/25/2017	5.00	7/17/2012	1310
OAT	FR0011317783	2.75	9/11/2012	10/25/2027	15.12	9/3/2012	1462
OAT	FR0011337880	2.25	10/9/2012	10/25/2022	10.04	10/2/2012	1441
OAT	FR0011394345	1	1/22/2013	5/25/2018	5.34	1/15/2013	1366
OAT	FR0011452721	0.25	3/26/2013	11/25/2015	2.67	3/20/2013	700
OAT	FR0011461037	3.25	4/4/2013	5/25/2045	32.14	3/27/2013	1315
OAT	FR0011486067	1.75	5/7/2013	5/25/2023	10.05	5/2/2013	1289
OAT	FR0011523257	1	6/25/2013	11/25/2018	5.42	6/19/2013	1255
OAT	FR0011619436	2.25	11/12/2013	5/25/2024	10.53	11/5/2013	1156
OAT	FR0011708080	1	1/28/2014	5/25/2019	5.32	1/21/2014	1101
OAT	FR0011857218	0.25	4/23/2014	11/25/2016	2.59	4/15/2014	679
OAT	FR0011883966	2.5	5/6/2014	5/25/2030	16.05	4/28/2014	1032
OAT	FR0011962398	1.75	6/10/2014	11/25/2024	10.46	6/3/2014	1006
OAT	FR0011993179	0.5	6/24/2014	11/25/2019	5.42	6/17/2014	994
OAT	FR0012517027	0.5	2/9/2015	5/25/2025	10.29	2/3/2015	831
OAT	FR0012557957	0	2/23/2015	5/25/2020	5.25	2/17/2015	821

Table A5
Summary of the Nominal BTAN and OAT Securities, Issues 2015−2018. This table shows the sample of the nominal BTAN and OAT securities issued from 2015 to 2018. Column "Type" refers to the type of the security (BTAN or OAT), "ISIN" — to the ISIN number, "Coupon" — the coupon rate in percent,"First quote" — the first available quote date, "Maturity date" — the expiration date, "Term" — the term-to-maturity, "N obs." — the number of available daily observations for the security. Dates are in the mm/dd/yyyy format. Source: Bloomberg.

Type	ISIN	Coupon	Issue date	Maturity date	Term	First quote	N obs.
OAT	FR0012634558	0	3/23/2015	2/25/2018	2.93	6/9/2015	20
OAT	FR0012938116	1	9/7/2015	11/25/2025	10.22	9/1/2015	681
OAT	FR0012968337	0.25	9/21/2015	11/25/2020	5.18	9/15/2015	671
OAT	FR0012993103	1.5	10/5/2015	5/25/2031	15.64	9/29/2015	661
OAT	FR0013101466	0	1/25/2016	2/25/2019	3.09	1/19/2016	581
OAT	FR0013131877	0.5	3/7/2016	5/25/2026	10.21	3/1/2016	551
OAT	FR0013154044	1.25	4/19/2016	5/25/2036	20.10	4/13/2016	520
OAT	FR0013154028	1.75	4/19/2016	5/25/2066	50.10	4/13/2016	520
OAT	FR0013157096	0	4/25/2016	5/25/2021	5.08	4/20/2016	515
OAT	FR0013200813	0.25	9/5/2016	11/25/2026	10.22	8/30/2016	412
OAT	FR0013219177	0	11/21/2016	5/25/2022	5.51	11/15/2016	366
OAT	FR0013232485	0	1/23/2017	2/25/2020	3.09	1/17/2017	321
OAT	FR0013234333	1.75	1/31/2017	6/25/2039	22.40	1/25/2017	315
OAT	FR0013250560	1	4/10/2017	5/25/2027	10.12	4/4/2017	266
OAT	FR0013257524	2	5/25/2017	5/25/2048	31.00	5/17/2017	235
OAT	FR0013283686	0	9/25/2017	3/25/2023	5.49	9/19/2017	146
OAT	FR0013286192	0.75	10/9/2017	5/25/2028	10.63	10/2/2017	137
OAT	FR0013311016	0	1/22/2018	2/25/2021	3.09	1/16/2018	61
OAT	FR0013313582	1.25	2/5/2018	5/25/2034	16.30	1/29/2018	51

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