



Swiss treasury bill auctions: A review

Enzo Rossi

SNB Economic Studies

12/2024



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ISSN 1661-1438 (online version)

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P.O. Box, CH-8022 Zurich

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Enzo Rossi*

+ The author is grateful to Daniel Wittwer and the rest of the Swiss Treasury team as well as Roman Baumann, Lucas Marc Fuhrer and Angelo Ranaldo for helpful comments and suggestions; Evelyn Ingold for assistance in collecting the data; and Amadeo Grob for invaluable graphical support. The views expressed in this study are those of the author and do not necessarily reflect those of the SNB.

* Swiss National Bank and University of Zurich. Swiss National Bank, P.O. Box, CH-8022 Zurich; enzo.rossi@snb.ch.

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Abstract

The Swiss National Bank (SNB) has conducted sealed-bid, uniform-price auctions for allocating T-bills on behalf of the Treasury since July 1979. This study describes the development of auction rules and summarises the results in terms of bidders' behaviour and auction outcomes. From July 1979 to December 2020, the SNB held 1,634 auctions, all well covered. T-bills have been a stable and reliable source of funding for the treasury through which it borrowed CHF 1.121 trillion. There is clear evidence of a marked increase in the demand for T-bills by private investors following the introduction of noncompetitive bids, sustained broad-based interest despite a steady decline in yields since the 1990s, an extraordinary demand boost after the global financial and European sovereign debt crises, and net revenue from T-bill borrowing of CHF 502 million.

JEL classification: D44; G12; G20; H63

Keywords: Treasury bills, treasury auctions, uniform-price auction, negative yields, safe assets, public debt management

1. Introduction

According to the Revised Guidelines for Public Debt Management, prepared by the IMF and World Bank staff (IMF, 2014, p. 7), “the main objective of public debt management is to ensure that the government’s financing needs and its payment obligations are met at the lowest possible cost over the medium to long run, consistent with a prudent degree of risk.” Different issuing techniques are available to debt managers to meet this objective. Before the 1980s, most countries would place a large share of their debt with domestic banks, either directly or through a bank syndicate arrangement. Currently, auctions are the most common issuing method for government securities.

Switzerland was one of the first countries in the OECD (Organisation for Economic Co-operation and Development) area to replace syndication as an allotment mechanism for treasury securities with auctions. In July 1979, the Swiss National Bank (SNB), after years of preparatory work, began selling short-term securities, so-called money market debt register claims, henceforth T-bills, by auctions on behalf of the Swiss treasury, treasury hereinafter. From the beginning, the sealed, multiple-bid, uniform-price technique has been applied, also referred to as rate tender with the Dutch or single rate allocation procedure. Swiss T-bills are tradable, short-term pure discount securities; that is, they have no coupon rates and mature in one year or less. Issuance is normally at a price that is less than 100 percent of the nominal value with redemption at 100 percent, yielding a positive interest rate for investors. Conversely, if the issuance price is above par, investors face a negative interest rate. T-bills are essential for fulfilling the treasury’s mandate to cover the Confederation’s financial needs in the short term, well suited for the short-term management of liquidity holdings and eligible as collateral in repo transactions with the SNB.

The Swiss case is interesting for several reasons. First, the auction procedure bears a few unique characteristics compared to those in other countries. Bidders in sovereign debt auctions typically fall into one of three categories: primary dealers, dealer clients (indirect bidders), and direct bidders. Primary dealers are financial institutions appointed by sovereign issuers to buy, promote and distribute government securities. In most OECD countries, a selected group of primary dealers constitutes the major bidder class. Primary dealers provide significant services to issuers by supplying information on the likely state of demand in advance of an issue, ensuring that the conditions for achieving the treasury’s target are met and helping market security. For their services, primary dealers are entitled to different forms of compensation. In some countries, participation in government securities auctions is limited to primary dealers. In contrast, the Swiss treasury has never installed a formal primary dealer system, neither for bills nor for bonds. Instead, it relies informally on banks and institutional and private investors without granting them the rights or obligations of market makers and formal compensation. Hence, bidders in our data can be categorised as direct bidders and indirect bidders.

Second, since the introduction of auctions as the main allocating mechanism, only the uniform-price format has been used for all maturities. Switzerland is one

of the few countries that has used the same auction format over time. No structural break in the data from a change in the auction procedure needs to be taken into consideration.

Third, while the Confederation has experienced a steady decline in the public debt ratio since the mid-2000s, in the 1990s, it faced periods with accelerating budget deficits. An analysis of the workings of T-bill auctions under circumstances of tightening borrowing requirements may yield important lessons for the future.

Fourth, studying the evolution of auctions is an important first step in advancing the authorities' understanding of auctions' functioning. This knowledge is essential to answer questions regarding the workings of the treasury markets, which are the bedrock of the modern financial system. Auction results are regarded as a test of the market's assessment of sovereign securities and its risk appetite. When funding conditions are under stress, treasury auctions move to centre stage in terms of public attention.

Despite their importance in funding the Confederation's financing needs, there has been no formal analysis of Swiss T-bill auctions. This is the motivation for this study, whose purpose is to review four decades of experience with T-bills. It makes three major contributions. First, it compiles a dataset that covers all T-bill auctions conducted by the SNB from 19 July 1979 to 29 December 2020. Four decades of auction data represents an exceptionally long time series dimension to be exploited in empirical work, which is typically limited to a couple of years. Second, this study tracks the evolution of auction rules and discusses the most important changes. Third, it summarises the outcomes produced by the auction process.

The main results are as follows: A total of 1,634 T-bill auctions have been held during the past four decades. The quantity rose steadily, from 130 in the first decade to 409 in the second, 521 in the third and 574 in the last. All the auctions were well covered and enabled the treasury to borrow CHF 1.121 trillion. The borrowed sum continued to increase in the first three decades. Starting from a sum of CHF 25.843 billion in the first ten years, borrowing jumped to CHF 346.090 billion in the subsequent decade, followed by a further rise to CHF 407.354 billion in the third decade before decreasing to CHF 342.035 billion in the last decade. Noncompetitive bidders have been a stable source of funding. The period after the global financial crisis (GFC) and the European sovereign debt crisis has been characterised by an extraordinary rise in demand for T-bills. Since 2011, following the removal of the bid price limit of 100 %, auctions have closed above par, meaning negative yields for investors. This corresponds to 29.8 percent of all auctions. The revenue to the Confederation through negative yields amounts to CHF 502 million. This raises questions about the potential of T-bills for generating additional revenue in the future.

The rest of this study is organised as follows. Section 2 illustrates Switzerland's financial situation over the past decades, followed in section 3 by a description of the institutional setup and the division of labour between the treasury and the SNB. Section 4 reviews the literature on optimal maturity choice, safe assets, and treasury auctions. Section 5 describes the data sources used for the empirical part of the analysis and provides summary statistics. Section 6 discusses the main changes to the auction procedure implemented over time. Section 7 presents the results, and section 8 concludes this study. The Online Annex contains the main results broken down by auction.

2. Public sector finance

Since the 1970s, the government debt-to-GDP ratio in advanced economies has been on a generally upward trajectory (Yared, 2019). Switzerland has been no exception. For years, the federal budget tended to display an asymmetric pattern where the deficits accumulated during recessions were not compensated for by corresponding surpluses during boom phases. The result was a permanent rise in federal (marketable and nonmarketable) debt, which increased from CHF 11 billion in 1970 to CHF 130 billion in 2005. A large share of the debt was used to finance accumulated deficits and restructure old debts (Hausner and Simon, 2015). During the 1990s, the deficits of the consolidated public sector, which also includes the communes and cantons, reached 5 percent of GDP, with debt rising to over 50 percent of GDP by the end of the decade (Bodmer, 2006).

The period of rising federal budget deficits and debt required unanticipated increases in issuances of securities. In 1992, the treasury had to raise a net record amount of CHF 8.9 billion (up from 2.7 billion in 1991) on the money and capital market (Thomann, 1993). In this period, several changes to the auction procedure and other measures were implemented to cope with the increased demand for funding.

After this worrisome trend, fiscal policy was fundamentally transformed. The key was the introduction of a debt brake, which was applied for the first time to the 2003 budget.¹ Designed to avert chronic structural imbalances and prevent debt from soaring again, as in the 1990s, the debt brake ensures countercyclical fiscal policy by permitting deficits during economic downturns and requiring surpluses when the economy is thriving. Eventually, debt is stabilised over an economic cycle, while the debt ratio declines by virtue of economic growth. In extraordinary circumstances, the rule's expenditure ceiling can be raised by a qualified majority of the Federal Assembly. Deficits in the extraordinary budget have to be offset via the ordinary budget in the medium term. An amortisation account serves as a control parameter. A deficit on this account is to be paid off over the course of the subsequent six accounting years by means of structural surpluses in the ordinary budget. In special cases, the Federal Assembly can extend the deadline for debt reduction. The constitutional article on which the debt brake is based was accepted with a "yes" vote of 85 percent in a popular vote on 2 December 2001, indicating extraordinarily strong public backing.²

Experience to date shows that the desired objectives envisaged by the debt brake have been achieved. The strict implementation of the rule has led to a reduction in relative and absolute terms in Confederation debt, which fell to 13.3 percent of GDP in 2019 from a peak of 25.3 percent in 2002. All the relevant rating agencies have given the Confederation's creditworthiness the highest rating, which very few countries have maintained in the wake of the GFC. Some authors have even questioned

1 The debt brake is laid down in Article 126 of the Federal Constitution. The details are set out in Articles 13 to 18 of the Financial Budget Act (SR 611.0).

2 As a reaction to the rising debt trend, governments across the world have adopted fiscal rules such as mandated deficit, spending, or revenue limits. In 2015, 92 countries had fiscal rules in place, compared with only seven in 1990 (Lledó, Yoon, Fang, Mbaye, and Kim, 2017).

whether this development has progressed too far, especially at times when the cost of the debt has fallen to even negative values (Bacchetta, 2017).

Unlike the treasuries in some other countries, the Swiss treasury maintained its T-bill programme even when borrowing needs declined. Maintaining this presence in the market prevents incurring reentry costs and offers a short-term security valued by investors. The maintenance of an active T-bill market particularly paid off when the COVID-19 pandemic placed a great strain on public finance, proving the critical role that this market plays during periods of financial market stress. At the federal level, an extraordinary expenditure of CHF 31 billion was approved for 2020, but only part of it was ultimately used. Nevertheless, the extraordinary measures to support the economy – such as guarantees for bridging credits, support for short-term work, compensation for self-employed individuals and help for particularly hard-hit companies – pushed the Confederation’s deficit to CHF 17.7 billion in 2020, after a surplus of almost CHF 6 billion in 2019.

According to the 2020 issuance programme, the volume of outstanding T-bills was envisaged as remaining unchanged at CHF 6 billion. However, the extra expenditure to cushion the pandemic’s impact forced the treasury to adjust its borrowing programme, doubling the outstanding volume from CHF 6 billion to CHF 12 billion. Thanks to a liquidity buffer of CHF 23 billion, the additional funding requirement of CHF 22 billion was financed primarily by increasing the volume of T-bills by CHF 7 billion and reducing liquidity by CHF 10 billion. As a result, the Confederation’s market debt rise was contained from CHF 67 billion to CHF 74 billion (Treasury, 2021). The Confederation’s debt ratio reached 14.7 percent in 2020.

Chart 1 shows the evolution of the Confederation’s marketable debt since 1990 in comparison with the volume of T-bills and their share of marketable debt. At the beginning of the 1990s, the massive accumulation of debt was funded mainly by

Chart 1: CONFEDERATION DEBT AND T-BILLS’ SHARE

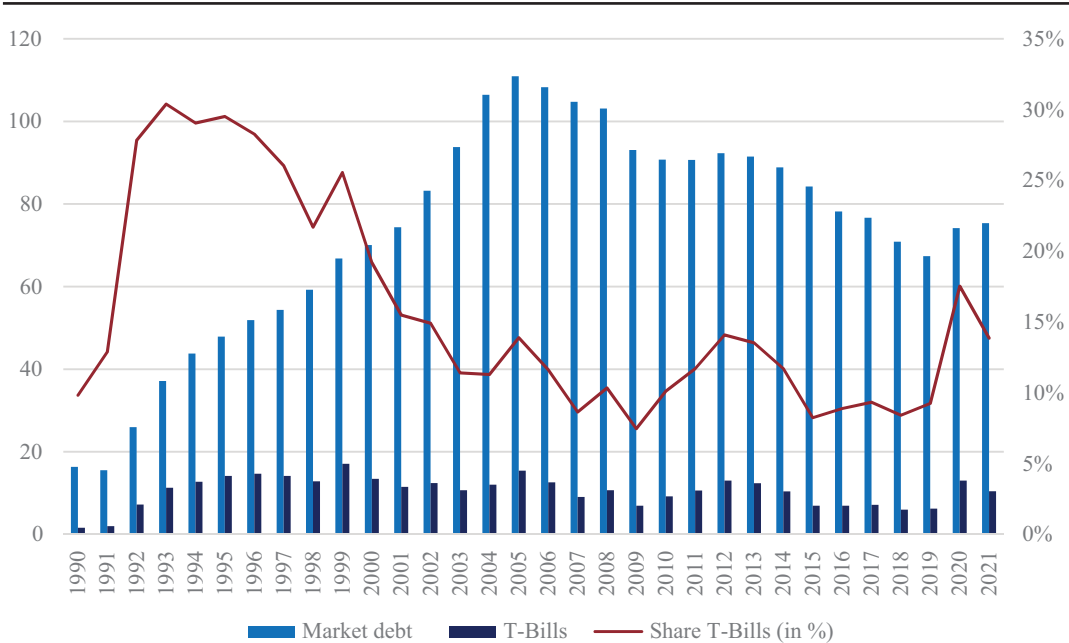


Chart 1: Total Confederation marketable debt and volume of T-bills in million Swiss francs at year-end (left-hand scale) and share of T-bills in total debt (right-hand scale).

T-bills, which reached a share of 30 percent in 1995. Since then, the share of T-bills has trended downwards, falling as low as seven percent in 2009. The outbreak of the COVID-19 pandemic and concomitant additional public expenditure again accompanied a strong increase in T-bill funding, whose share reached 18 percent in 2020, similar to that in 2000. In mid-March 2020, the treasury experienced unusually high net cash outflows when the government announced a multibillion-CHF package of measures to cushion the shock. The volume of T-bills grew quickly. When it became apparent in the summer that the fiscal impact would be less severe than anticipated, the treasury reduced its T-bill issuance.

3. Institutional setup

The two main actors with respect to T-bill auctions are the treasury and the SNB. Their functions are summarised in the next two subsections.

3.1 Federal Treasury

According to Art. 60 para. 1 of the Financial Budget Act, the central treasury ensures the Confederation's ability to fulfil its payment obligations at all times. The treasury's mandate can be broken down into three main tasks: liquidity management, foreign exchange management and debt management. With regard to (i) liquidity management, the treasury is responsible for assuring an appropriate level of liquidity to even out fluctuations, low-risk short-term investment of liquidity or coverage of shortfalls. Liquidity is to be limited to the level required as security for events that are unexpected or cannot be planned for. The Federal Finance Administration's (FFA) Asset and Liability Management Committee (ALCO) sets a target range for the treasury's liquidity position. (ii) Foreign exchange management includes the procurement of foreign currencies for planning certainty. (iii) Concerning its debt management functions, the treasury bears the responsibility for covering the Confederation's financial needs "by means of funding in the money and capital market at the lowest possible cost and with an acceptable degree of risk" (Treasury, 2021, p. 7).

The treasury has hardly any leeway regarding the debt volume, but this leeway affects interest payable. Since the interest rates for short maturities are generally lower than those for long maturities, the average interest burden may be reduced by issuing more short-term debt instruments. While the costs are relatively easy to summarise in terms of interest payments, measuring the risks associated with debt management is more difficult, as it requires taking a stand on what these risks might be. The two main risks that the treasury references are interest rate risk and refinancing risk.³ (1) Interest rate risk is the risk that interest rates will increase, which leads to higher funding costs. In general, unexpected changes in interest rates lead to higher fluctuations in interest expenditure, making interest expenditure more difficult to plan and impinging on the leeway for budgeting other expenditures.⁴

3 In addition to interest rate and refinancing risks, the treasury must take forex and counterparty risks into account in performing its main tasks.

4 As part of its debt management responsibility, the treasury limits the annual fluctuations in interest payable to ensure planning accuracy (Treasury, 2014).

(2) Refinancing risk means the risk that refinancing may only be possible under unfavourable market conditions or, in an extreme situation, even prove impossible, essentially leading the government to become illiquid. A classic trade-off arises. The issuance of large volumes of short-term debt instruments leaves government budgets exposed to changing conditions when the debt has to be refinanced. Conversely, by issuing long-dated instruments, both risks can be reduced, but at the cost of higher interest expenditure on average.⁵

In comparison with other countries, the Swiss treasury focuses exclusively on the domestic market in Swiss francs. Most of the debt sold by the treasury is marketable, meaning that it can be resold on the secondary market. The two main instruments are T-bills, with maturities of three, six and twelve months, and bonds that offer a fixed interest rate for maturities ranging from more than one year to 50 years. Other countries that face higher debt and thus can afford more diversification in funding instruments, resort to foreign currency, inflation-protected (“linkers”) or variable-rate securities, and more recently, green bonds.⁶ However, Switzerland’s debt portfolio differs relatively little from those of other OECD countries. Its proportion of money market debt is slightly above average, while fixed-rate bonds issued in the domestic market are also the preferred instrument for long-term funding in other countries (Treasury, 2017).

The treasury estimates the funding requirements for the budget and financial plan years using internal projections. On this basis, auction dates are announced in December for issuance of T-bills and bonds. The calendar also provides information about the total bond issuance volume planned for the year and the target volume of outstanding T-bills at year-end.⁷

3.2 Swiss National Bank

Based on Art. 5 para. 4 of the Federal Central Bank Act, the SNB acts as the bank for the federal government. As the treasury’s fiscal agent, the SNB provides services on behalf of the government’s administrative divisions. The issuance of T-bills and bonds falls under this mandate. The SNB is not responsible for making debt issuance decisions; this responsibility rests solely with the treasury to ensure the independence of the two institutions.

In the 1970s, the treasury instructed the SNB to establish a Swiss money market. At the time, Swiss financial institutions used foreign money markets to balance their

5 This trade-off arises time and again. For instance, in 1993, some of President Clinton’s economic advisers argued that it would be desirable to shorten the average maturity of the government debt to lower the cost of funding (Greenwood, Hanson, Rudolph and Summers, 2015). In a counterfactual analysis, Greenwood, Hanson, Rudolph and Summers (2015) obtained large cost savings in the US from borrowing and rolling over T-bills with three-month maturity. Sophisticated analyses by Belton, Dawsey, Greenlaw, Li, Ramaswamy, and Sack (2018) concluded that issuing at intermediate maturities is appealing. Ellison and Scott (2020) found a substantial cost advantage from short bonds on UK data, even when considering some of the operational risks implied by cash flows and gross redemptions.

6 In October 2022, the treasury issued its inaugural green Confederation bond maturing in 2038, raising CHF 766 million at an annual yield of 1.47 %.

7 For an empirical analysis of the Confederation’s debt management since 1970, cf. Guggenheim, Meichle, and Nellen (2019).

liquidity excesses or shortages. Financial institutions had an interest in top-rated local debtors of short-term debt instruments, such as the SNB or the treasury. To reduce its funding cost, the treasury envisaged restructuring its debt portfolio by shifting long-term to short-term funding, whose share at the end of 1978 was only 6.8 percent of total debt (NZZ, 1980).

The SNB started preparatory work in 1974 together with representatives of the federal government and financial institutions. This work culminated in the first uniform-price auction for T-bills on 19 July 1979. In 1980, prompted by the success of the T-bill auctions, the authorities also adopted the uniform-price format for treasury bonds. According to Ranaldo and Rossi (2016), the authorities' main reasons for choosing the uniform-price format were equality of treatment, the proximity of the auction price to the secondary market price, and the relative simplicity of computing the market-clearing price.

4. Literature

The choice of borrowing instruments and methods is central to sovereign debt management. In this section, we first survey issues relating to optimal debt maturity discussed in the literature, followed by a brief overview of the literature on safe assets and treasury auctions.

4.1 Approaches to optimal public debt management

The substantial deterioration in public finances since the GFC – and exacerbated by the COVID-19 crisis – has raised government debt to (renewed) prominence. While there has been considerable debate over the impact of public debt and its appropriate level, analyses about what type of debt to issue are relatively limited. However, if government finances are not well managed, financial stability and economic growth could be at risk. Poorly structured debt portfolios, in terms of maturity, currency, or interest rate composition and large contingent liabilities, have induced or propagated economic crises in many countries throughout history. Crises have often arisen because of an excessive focus on possible cost savings associated with short-term or floating-rate debt. Heavy reliance on short-term financing amplifies near-term refinancing risk, as maturing debt needs to be refinanced several times within a short period of time at new market interest rates. A long (and balanced) maturity structure helps prevent a confidence crisis in which investors refuse to roll over the debt because they are afraid that everyone else will do the same.⁸ In addition to making a country less susceptible to contagion and financial risk, a debt portfolio that is robust to shocks places the government in a better position to manage financial crises.

An important body of theoretical literature argues that governments should borrow using state-contingent debt to smooth fluctuations in domestic consumption

8 Alesina, Prati and Tabellini (1990), Cole and Kehoe (1996, 2000), and Bohn (2011) showed that rolling over too much short-term debt might make the government vulnerable to bank-run type problems, forcing it to default.

or tax rates.⁹ However, favourable risk-return combinations can also be obtained by conventional debt instruments. Faraglia, Marcet and Scott (2008) named this approach “the fiscal insurance theory” of debt management.¹⁰

Despite the emphasis in theoretical writings on macroeconomic objectives whose focus is on risks that can be measured by the covariance of bond prices with various macroeconomic shocks, debt managers in practice envisage narrow financial goals; a much wider set of risks, such as rollover, interest rate, and operational risk (IMF, 2014; Ellington and Scott, 2020); and no reference to macroeconomic goals (Kappagoda, 2001; Holler, 2013). This approach has been labelled the “micro-portfolio approach” to debt management (Blommestein and Hubig, 2012).¹¹

However, interest has recently been revived in the macroeconomic effects of public debt management. This development has given rise to two nontraditional objectives of debt management in which maturity shortening can make a difference (Greenwood, Hanson, Rudolph and Summers, 2015). On the one hand, the maturity structure of public debt is considered a tool of aggregate demand management. A reduction in debt maturity lowers the amount of interest rate risk that fixed income investors have to bear, leading to a decline in term premia due to a Tobin-style portfolio balance effect. This may even be one of the few available tools for combatting high unemployment and the threat of deflation once nominal interest rates reach the (effective) zero lower bound. On the other hand, maturity shortening is seen as instrumental in promoting financial stability. An abundant supply of safe, liquid short-term government securities crowds out excessive creation of short-term bonds by commercial banks to finance their long-term loan commitments.¹²

4.2 Safe assets

According to Gorton (2017), history can be written in terms of the search for and production of safe assets. A safe asset may be defined as a debt instrument that is expected to preserve its value during adverse systemic events with no questions asked (NQA), that is, without expensive and prolonged analysis (Caballero and Farhi, 2018). Four characteristics associated with safe debt are emphasised: “safety,” “moneyness” (or “money premium”), “liquidity premium” and “convenience yield”.

(i) “Safety” refers to long-term debt that holds its (nominal) value over time and that will pay off at par with high probability. Treasury bonds or AAA asset-backed securities are typical examples. (ii) “Moneyness” and (iii) “liquidity premium” are usually used synonymously and refer to NQA, an attribute of short-term debt, such as T-bills, commercial paper, and repo. (iv) The specialness of safe assets implies the existence of nonpecuniary returns, a convenience yield that investors receive from

9 For instance, Bohn (1990), Calvo and Guidotti (1993), Barro (2003), and Lustig, Sleet, and Yeltekin (2008).

10 Missale (2012) surveyed this body of literature.

11 There are empirical studies on debt managers’ reaction functions in the spirit of those analysed for central banks that inform actual debt managers’ practice. For an overview of this literature, cf. Wolswijk (2020).

12 Cf. Pozsar (2011, 2012); Krishnamurthy and Vissing-Jorgensen (2013); Greenwood, Hanson and Stein (2015); and Greenwood, Hanson, Rudolph and Summers (2015).

holding a safe, money-like asset with absolute safety of nominal cash flow. The safe assets literature essentially posits that a country's convenience yield rises when the opportunity cost of holding money increases.¹³

Government securities may be considered safe assets, characterised by high liquidity, stable (nominal) payoffs and absence of default risk.¹⁴ Empirical work documents that because of its special safety and liquidity services, US government debt earns a convenience yield.¹⁵ However, while long-term bonds offer long-term safety in the sense of absolute certainty of repayment, they are subject to interim market risk. T-bills come closest to a risk-free asset. As a result, their yields are lower than in standard asset-pricing models and offer cheaper financing conditions than longer-term government securities.¹⁶

A related expression of the specialness of T-bills is that they are typically considered shock absorbers by sovereign debt managers (OECD 2021, Box 1.1). In the case of an unexpected rise in funding requirements, as happened in the wake of the GFC and the COVID-19 pandemic, there are uncertainties regarding the size and duration of revenue shortfalls and government expenses. T-bills help manage uncertainties regarding financing requirements. As T-bills are deemed the safest and most liquid assets in times of crisis, demand for them is likely to be particularly strong in times of increased financial instability and uncertainty, leading to a decline in yields and hence costs.¹⁷

Swiss T-bills and bonds share many of the attributes of safe securities, but there is little related research.¹⁸ Swiss T-bills can even be considered the quintessential

13 When interest rates are positive, cash and deposits are close substitutes in terms of liquidity provision. As earning interest is the opportunity cost of holding cash, the nominal interest rate must be equal to the convenience yield on cash and determine the magnitude of the convenience yield on non-cash assets (Nagel, 2016). When interest rates are negative, the effort of storing cash or other physical assets is not shared by deposits or other electronic assets, and the relationship between interest rates and the convenience yield breaks down (Diamond and Van Tassel, 2022).

14 Government-issued fiat currency is a notable example of a safe asset except for inflation.

15 Cf. Krishnamurthy and Vissing-Jorgensen (2012), Nagel (2016), van Binsbergen, Diamond, and Grotteria (2022).

16 Cf. Greenwood, Hanson, Rudolph and Summers (2015); Golec and Perotti (2017); and Habib, Stracca and Venditti (2020). Similarly, Carlson, Duygan-Bump, Natalucci, Nelson, Ochoa, Stein and Van den Huevel (2016) found in an experiment that the longer the maturity is, the lower is the convenience yield.

17 In 2020, similarly to Switzerland, other OECD countries intensified their reliance on short-term debt instruments as a reaction to challenges in cash-flow forecasting and management of the resulting cash positions. Many sovereigns also issued T-bills to boost liquidity buffers against possible changes in cash needs. As a result, the share of short-term instruments increased from 40 percent to 48 percent (OECD, 2021).

18 According to Diamond and Van Tassel (2022), high nominal-rate currencies such as Australia, Norway, and Sweden have the highest average convenience yields of up to 60 basis points, while low-rate currencies Switzerland, Denmark, and Japan exhibit average convenience yields as low as two basis points. Bacchetta, Benhima and Renne (2022) even found the convenience yield on Swiss government bonds to be negative. The authors argued that the purchase of government bonds by foreign central banks and foreign exchange interventions by the SNB reduced the relative supply of foreign versus Swiss government bonds, which made them less scarce, contributing to the recent decline in the convenience yield.

extremely safe short-term asset that offers many liquidity services, reflected, for example, by their wide acceptance as collateral in repo contracts. Swiss T-bills are also special due to the lack of alternative safe or near-safe assets in the Swiss financial market. For example, Pfandbriefe are typically longer-term investments, and relatively few commercial papers are issued. Other short-term safe assets such as repos are typically traded on the interbank market and are only indirectly accessible to nonbanks. For the latter, T-bills represent the only truly safe short-term asset that they can always rely on to park liquidity. Often, bank accounts are used to this end. However, they expose investors to counterparty risk. In times of crisis, as during the GFC, bank accounts have turned out to be quasi-safe assets. For investors without a sight deposit with the SNB (and for whom the forex swap market is not readily accessible), the only possible means to safely roll over liquidity are the bills issued by the Swiss treasury.¹⁹

Another special feature of Swiss T-bills is related to the safe-haven status of the Swiss franc. The literature has shown that there is a link between the US dollar and demand for safe assets (Jiang, Krishnamurthy and Lustig, 2021). A similar mechanism may emerge for Swiss T-bills. This is an avenue for future research.²⁰

4.3 Selling techniques

Treasury securities are put up for sale through different methods, including auctions, syndications, private placements and taps (OECD, 2021).

4.3.1 Auctions

Most OECD countries use auctions to place their government securities.²¹ The main reason for the popularity of auctions is that they are market-oriented. A seller does not know the bidder's valuation of the good or security to be sold, and an auction allows the market to set the price. Although auctions are thought to generate a close-to-market price, the decision about which auction format to implement is not straightforward. There are different types that provide different incentives for bidders and whose outcomes very much depend on a variety of circumstances.

In this subsection, we discuss the two main auction formats used by sovereigns for selling securities and their effect on bidding behaviour. First, a basic distinction concerns the organisation of auctions as either open-outcry or sealed-bid events. Another important distinction refers to the number of units put up for sale. Either an indivisible unit is being auctioned (or only one single unit is bid for in a multiunit auction) or more units of the same item can be purchased.

19 Ballensiefen and Ranaldo (2022) showed empirically on data from the European repo market that the convenience yield determines the time series and cross-section variation of short-term interest rates.

20 Surveys of the expanding literature examining safe assets' supply, demand, and convenience premium include Caballero, Farhi, and Gourinchas (2017) and Gorton (2017).

21 29 debt management offices (88 percent) use auctions for issuing long-term debt, while 28 (85 percent) also rely on auctions for selling short-term debt (OECD, 2016, Table 4.1).

4.3.1.1 Single-unit auctions

In an open-outcry sale of a single unit, the current winning bid is announced by the auctioneer and therefore known by all participants.²² In a sealed-bid auction, each bidder independently submits a bid without knowing the bids of other participants. Two basic formats determine the price. In a first-price sealed-bid auction, the bidder with the highest bid wins the auction at the bid price. In a second-price sealed-bid auction, the bidder with the highest bid wins the auction but pays only the second-highest price.²³

4.3.1.2 Multiunit auctions

In multiunit auctions of the same good, bidders usually do not post a mere single bid but rather post a collection of bids (demand schedules) that specify the number of units that they are willing to buy at each price. Treasury auctions belong to this type of auction. Two basic procedures are used in practice: a discriminatory-price auction (DPA) and a uniform-price auction (UPA). In both, items are awarded in order of descending price until the supply is exhausted. The only difference between a DPA and a UPA concerns payment. In a DPA, the treasury acts as a perfectly discriminating monopolist by awarding the security to the highest bidder and working its way down until the entire amount is sold. Since winning bidders are allocated their own bids, this auction is also called a pay-as-bid, bid price, multiple-price or multiple-yield auction. In a UPA, each successful bidder pays the market-clearing price, also called the stop-out price or cut-off price, for all the units awarded, which is why it is also referred to as a single-price auction.²⁴

Since the 1960s, there has been an intensive debate about the most appropriate auction procedure for treasury securities. Milton Friedman (1959a,b) recommended that the US treasury sell securities by (regularly scheduled) auctions rather than fixed-price offerings because of the difficulty of setting the yield at a level where investors would buy the full amount offered. Friedman argued that the choice between a DPA and UPA critically affects participation and the level of price bid, particularly where uncertainty is high. Switching from the then-used DPA for T-bills to the UPA would ease the bidding process by reducing bid preparation costs and broaden participation, lower the cost of financing the debt by alleviating bid-shading incentives, and narrow the scope for brokers to collude and corner markets. The

22 An example is Leonardo da Vinci's *Salvator Mundi*, which fetched more than USD 450 million at Christie's New York in 2016 after a drawn-out 19-minute-long bidding made it the most expensive artwork ever sold at auction.

23 The second-price sealed-bid auction is much studied in the literature but uncommon in practice. One notable exception is Johann Wolfgang Goethe in 1797. After completing a new poem titled *Hermann and Dorothea*, Goethe was interested in knowing and publicising the poem's "true worth". To this end, Goethe concocted a scheme with his lawyer, essentially a second-price sealed-bid auction, and presented it in a letter to his publisher (Cf. Moldovanu and Tietzel, 1998). This type of auction was formally described only in 1961 by William Vickrey and for this reason is sometimes referred to as a Vickrey auction.

24 There is some confusion in the terminology. In the financial community the uniform price auction is referred to as the "Dutch" auction. Similar confusion arises around the discriminatory auction. In the financial community this type of auction is referred to as an English auction, except in the United Kingdom, where it is called an American auction.

increased demand would more than offset the loss of the treasury's discriminating power in the process.²⁵

An important finding from auction theory regarding indivisible goods is that a second-price auction yields more revenue on average than a first-price auction. Since a DPA shares some features with a first-price sealed-bid auction while a UPA has similarities to the second-price sealed-bid auction, a number of authors applied the insights from the auction theory of indivisible goods to multiunit auctions. Invoking this reasoning, they recommended that the US treasury switch from DPAs to UPAs.²⁶ Specifically, Friedman (1991) and Chari and Weber (1992) pointed out that a UPA not only leads to higher revenues for the treasury but also limits the possibilities for market manipulation.

One major advantage of the UPA compared with the DPA format is due to the "winner's curse", one of the most celebrated phenomena in common-value auctions. In common-value auctions such as treasury auctions, the winner's curse is considered less relevant in UPAs than in DPAs. In auctions of treasury securities, the realised common value is given by their secondary market price. Winning a security may indicate that other bidders possessed adverse information about its value. The risk of incurring monetary losses will induce bid prices lower than their own reserve price. The resulting auction clearing prices will be lower than resale prices on the secondary market. Analogous to the result reached by Milgrom and Weber (1982), who, among others, originally studied the winner's curse in the context of single-unit auctions, Milgrom (1989) and Bikhchandani and Huang (1993) argued that the UPA should reduce the winner's curse and generate more revenue (less underpricing) than the DPA.²⁷

A newer strand of literature concludes that multiunit auctions differ from auctions for indivisible goods and, therefore, "the results based on single-unit demands do not generalise to auctions in which bidders desire multiple units" (Back and Zender, 1993, p. 735). As noted by several authors, including Wilson (1977); Back and Zender (1993); and Ausubel, Cramton, Pycia, Rostek and Weretka (2014), the UPA is susceptible to arbitrarily substantial underpricing (bid shading) as a result of the market power of larger bidders, which arises endogenously. As shown theoretically by Back and Zender (1993), a UPA could result in a loss of revenue to the treasury compared with a DPA if bidders submit sufficiently steep demand

25 The US treasury adopted auctions as its preferred method of marketing T-bills in 1929 (Garbade 2008) and coupon-bearing securities in 1970. Auctions became the preferred method of selling long-term securities in the 1970s (Garbade 2004). The discriminatory format was used for both. Friedman (1959b) made several suggestions to improve debt management practice. One suggestion was to sell both types of the marketable securities that he recommended, short-term (T-bills) and moderately long-term securities, only at auction. At that time, the treasury would only sell T-bills by auction. A concomitant suggestion of Friedman's was to substitute the discriminatory auction format with the uniform-price procedure for bills and bonds. Since October 1998, the US treasury has used the UPA for all auction offerings.

26 According to McAfee and McMillan (1987, p. 728) "theory predicts that the uniform-price auction, which is similar to the second-price auction, yields more revenue than the discriminatory auction, which corresponds to the first-price auction."

27 Since there were hardly any studies on this topic at the time, there is no evidence of the Swiss authorities invoking the winner's curse in rationalising their preference for the UPA (Ranaldo and Rossi, 2016).

schedules. The steepness of the demand schedules binds bidders to a self-enforcing collusive arrangement. If anyone deviates from the cartel, expected profits drop. This type of collusion takes place even though the bidders cannot observe the bids of others.

4.3.1.3 Peculiarities of treasury auctions

While having a number of features in common with other auctions, treasury auctions exhibit some characteristics that distinguish them from other markets (Das and Sundaram, 1997). One such feature is that bids for treasury securities may be submitted as noncompetitive or competitive. By submitting a noncompetitive tender, bidders exert the option to submit a bid up to a maximum amount without price. Noncompetitive bidders typically face no uncertainty about quantity but do not know the price at which their orders will be filled. They agree to accept the terms settled at the auction.²⁸ Under both formats, the clearing price is identified by equating the aggregate demand submitted by competitive bidders to the total issue amount minus the total demand from noncompetitive bidders. In the UPA, noncompetitive bidders pay the market-clearing price similarly to competitive bidders, and in the DPA, they pay a volume-weighted average price. The presence of noncompetitive bids may affect the bidding strategy of competitive bidders. When there are noncompetitive tenders, competitive bidders do not know at the time that they submit their bids the net amount of the security that will be available to them. This may change their strategy and result in more revenue being raised under a UPA.²⁹ As we will see, noncompetitive bidders have played an important role in Swiss T-bill auctions.³⁰

28 As we document below, noncompetitive bidders in Swiss T-bill auctions have more recently become subject to uncertainty regarding their allotted amount.

29 Back and Zender (1993) assumed that bidders are risk neutral. By relaxing the assumption of risk neutrality, Wang and Zender (2002) showed that if the amount of expected noncompetitive bids is high, risk-averse competitive bidders may not be willing to take the risk of submitting steep demand schedules because such schedules increase the chances of outcomes that are unfavourable to them. As a result, the collusive outcome under the UPA may not be realised, benefitting the treasury.

30 Treasury auctions differ from other auctions, for example, the well-known art and antique auctions, in other respects. In addition to the primary (auction) market on which this study focusses, one peculiarity of treasury auctions is that following the announcement of an auction but before issuance, there is often a forward market for newly auctioned securities. The forward contracts mature on the same day as the securities are issued. This forward market, known as the “when-issued” market, remains open during and after the auction. Before the auction, the “when-issued” market aggregates participants’ information, which affects the auction. Price movements in the “when-issued” market after the auction but before the announcement of results can give an indication of how efficiently this market reflects the information innovation contained in the auction. The “when-issued” market is a double auction where bidders can be buyers or sellers (Wilson, 1985). In contrast, a treasury securities auction is one in which all the bidders are buyers and the treasury is the only seller. A second difference is the “secondary market”, where participants not only buy and sell the auctioned securities in spot trading but can also borrow or lend their securities overnight on specified terms in the “repo market”. Each of these four markets plays a role in the distribution of treasury securities.

4.3.1.4 Empirical evidence

The literature discusses an array of variables that may affect bidders' behaviour and auction results. These comprise auction size, number of participants, participants' attitude towards risk, dispersion in participants' opinions, number of bids, competition, award concentration, demand restrictions, noncompetitive bids, ex-ante announcement of auction size, the right to cancel part of the supply, and market uncertainty.

Echoing the theoretical literature, empirical studies provide mixed results. Umlauf (1993) found indications of collusion among large bidders in Mexican DPA auctions. After a switch to the UPA, bidders' profits were eliminated. Feldman and Reinhart (1995) documented that the demand schedules in UPA gold auctions conducted by the International Monetary Fund were steeper than those in DPAs. Nyborg and Sundaresan (1996) assessed data from the US from July 1992 to August 1993, when both DPAs and UPAs were used in parallel. Their results did not give a clear indication of whether UPAs outperform DPAs. According to Hortaçsu and McAdams (2010), a switch to UPAs would not significantly increase revenues for the Turkish Treasury. Recent studies also report statistically insignificant differences between the two auction formats (Bonaldi, Hortaçsu, and Song, 2015; Barbosa, De Silva, Yang, and Yoshimoto, 2022).

In contrast, Marszalec (2017) found that Polish Treasury DPAs are revenue-superior to UPAs. Hortaçsu, Kastl and Zhang (2018) analysed bidding data from US Treasury UPAs of bills and notes from July 2009 to October 2013. Their results suggest that opportunities to exercise market power do exist and that primary dealers systematically bid lower prices than direct and indirect bidders. In contrast, Keloharju, Nyborg and Rydqvist (2005) rejected the market power theory in UPAs of the Finnish treasury. This was partly due to the treasury's strategy to determine supply after observing bids.

In a literature review, Monostori (2014) concluded that it is not possible to rank the two formats unambiguously. Instead, decisions should be made on a case-by-case basis depending on the circumstances. This ambiguity is also reflected in countries' choices. Twenty-three OECD countries (70 percent) exhibit a preference for the DPA format, while 12 countries use both UPAs and DPAs, depending on the maturity or type of debt instruments. Some countries issue index-linked bonds using a UPA and nominal bonds via a DPA.³¹ Switzerland is one of the few countries that has relied exclusively on UPAs for allocating T-bills and bonds.

4.3.2 Other selling techniques

4.3.2.1 Syndications

In addition to auctions, subscription-based syndications may be used as a complementary selling technique. In some countries, the inaugural issuance of an ultralong bond is completed through syndication, while the bond is then tapped via auctions. The reasons for this practice are a stronger primary dealer motivation to perform, flexibility in terms of timing independent of the auction calendar and easier price

31 Cf. OECD (2016, Table 4.1).

discovery during book building in the syndication process. Regarding the disadvantages, syndications involve intermediation costs, as lead managers demand fees for their services and require more human resources than auctions.

4.3.2.2 Private placements

Similar to syndications, private placements are used as a complementary selling technique to auctions. They are designed to meet the needs of a specific group of investors. Since a security is sold directly to the buyer, no agency fees are incurred. However, private placements come with a loss of transparency and heavy documentation requirements.

4.3.2.3 Tap issues

Many treasuries recur to tap issues (tap sales). In a tap, a past issuance is held back by the treasury as an own tranche and offered later at the original face value, maturity, and coupon rate but at the current market price. This procedure makes securities available to investors when market conditions are most favourable.

In Switzerland, auctions are the cornerstone of the treasury's allocation mechanism for its securities. Only occasionally has the treasury recurred to private placements in the last four decades.³² This did not change in the wake of the COVID-19 crisis, unlike in other OECD countries whose treasuries expanded syndications, private placements and supplementary noncompetitive auctions to gain additional flexibility in covering crisis-related expenditures (OECD, 2021). In addition to auctions, the treasury has intensified its tap issuances of bonds as it has done in the past whenever borrowing requirements have risen. In contrast, no T-bills have ever been sold by taps.

5. Data and summary statistics

This study's analysis required compiling and merging a large quantity of data. In this section, we describe the primary sources of the data and present summary statistics. Three different sources had to be tapped: dataset 1, a public dataset from the treasury, and datasets 2 and 3 from two confidential datasets, both provided by the SNB. All three datasets have strengths and weaknesses. Dataset 1 is available in electronic form and covers all auctions. However, the records provide only aggregate data. Dataset 2 is also available in electronic form but in addition includes the demand schedules broken down by banks and other direct bidders. Such granular data are rare in the empirical auction literature. As a downside, observations are limited to the period since the implementation of the electronic bidding platform in February 2001. Dataset 3

32 In addition to T-bills and bonds, which have been issued by auctions with great regularity, the treasury has in the past recurred to private and direct placements for the issuance of medium-term bonds. For fundraising in the short term, the treasury has also used securities discountable and acceptable as collateral instruments with a maturity from three to 24 months placed exclusively with banks (Schatzanweisungen). To cover liquidity peaks for a few days, it has also made use of money market loans provided by banks (Geldmarktkredite). In 1992 a Federal fixed deposit (Bundesfestgeld) with maturities from one to three years targeted at private investors was introduced, but it was discontinued in October 1999 (Thomann, 2003).

Table 1: SUMMARY STATISTICS

	Total	Average	Standard deviation	Minimum	Maximum
Bid volume (mio. CHF whole period)	2,880,429.715	1,839.355	1,286.325	85.600	17,106.300
Bid volume (mio. CHF) since 1990	2,855,896.355*	1,898.867*	1,277.771*	146.650*	17,106.300*
Allotted volume (mio. CHF) (whole period)	1,121,322.470*	686.244*	323.492*	67.100*	2,512.00*
Cut-off price (whole period)		99.596*	0.715*	95.648*	101.025*
Yield in percent (whole period)		1.379*	2.246*	-1.521*	9.102*
Cover ratio since 1990		2.908*	2.199*	1.000*	28.575*
Bids considered in percent (whole period)	38.929	50.853	25.939	3.500	100.000

Table 1: Summary statistics of bid volume, allocation, market-clearing price and yields, cover ratio and percentage of bids considered for the whole sample period and since 1990. Calculations based on the complete dataset are marked with *. Data without an * are incomplete. However, the number of missing auctions is limited to 68.

contains the most detailed information for the pre-electronic bidding period where bids were transferred to the SNB by mail, phone or fax. A limitation of this dataset is that it is available only in paper format and for the period from 1979 to November 1994.³³ Moreover, it is not consistent over time; for some auctions, the full demand schedules are available, and for others, only aggregate results are available. For reasons of consistency of information and completeness, at least at the aggregate level, and due to this study's purpose to overview four decades' experience with T-bills, dataset 1 is considered the most important, followed by dataset 2. Although it is the least important, dataset 3 provides information along several dimensions that is missing in datasets 1 and 2. The datasets are described in detail in the next subsections.

5.1 Dataset 1

Dataset 1 contains a total of 1,634 T-bill auctions conducted between 19 July 1979 and 29 December 2020. For each auction, the dataset includes the series number, auction date, value date, amortisation date, maturity, issued volume, volume of non-competitive bids, prices and yields and, since 1990, total volume of bids. No auction failed.³⁴ Table 1 displays summary statistics. Details are listed in the Online Annex.

33 For the period from December 1994 until January 2001, only aggregate information contained in dataset 1 is available.

34 Auction series 3.993, scheduled for 29 December 2008, was cancelled because the treasury deemed its liquidity situation sufficiently comfortable to justify a pause (EFV, 2008b). Another auction that we neglected is that held on 30 August 2010, which featured only one single bid described as "direct hit". This suggests a special agreement between the treasury and the bidder rather than an ordinary auction. This interpretation is corroborated by the fact that it is not listed in the treasury's records in dataset 1.

Five main patterns are noteworthy.

- (i) In total, bids summing to approximately CHF 2.9 trillion were tendered. The highest bid volume came in at the auction on 16 August 2011 for a 3-month T-bill (series 3.7927), totalling CHF 17,106.30 million. This auction was by all means extraordinary and will be further discussed. The lowest bid volume was recorded at the auction on 6 October 1987 (series 5.03) for a T-bill with annual maturity, collecting CHF 85.6 mio.³⁵
- (ii) There was remarkable variation in auction size. In total, CHF 1.121 trillion was raised by the treasury on the money market. This corresponds to an average of CHF 686.244 million per auction with a standard deviation of CHF 323.492 million. The smallest auction in terms of borrowed volume was on 18 December 2018 (series 3.8310), collecting CHF 67.10 million, while the largest, on 21 February 2012 (series 6.7954), raised CHF 2,512.00 million.
- (iii) Cut-off prices and yields were also subject to variation. The average market-clearing price was 99.596 with a standard deviation of 0.715. The lowest market-clearing price of 95.648 was recorded at the auction of a 6-month-maturity bill on 16 June 1992 (series 3.380), and the highest price of 101.025 was recorded at the auction of a 12-month bill on 5 July 2016 (series A.8182). On average, T-bills carried a (nominal) yield of 1.38 percent with a standard deviation of 2.25 percent. The lowest yield of -1.521 percent was established at the auction on 1 December 2015 for a 3-month bill (series 3.8151), while the highest yield of 9.102 percent resulted from the auction on 7 July 1992 (series 1.177) for a 6-month bill.³⁶
- (iv) In terms of the cover ratio (also called the “bid-to-cover ratio” or simply, “cover”), which is the ratio of the aggregate amount that investors bid to the amount that the treasury allocated, the auctions were successful. An average cover of two, as exhibited in Table 1, means ongoing demand for T-bills. The maximum of 28.6 denotes an extraordinary situation that occurred at the auction on 16 August 2011, where from a total of CHF 17,106 billion bids, only CHF 598.65 million was allocated.³⁷ On average, the treasury considered 50 percent of bids submitted with a range between 3.5 percent at the auction on 16 August 2011 and full allotment.³⁸

35 An outlier was the auction on 24 August 2010 (series 6.7876), where total bids amounted to CHF 146.65 million, well below preceding years.

36 The lowest price does not coincide with the highest yield because it was realised at an auction of a T-bill with a 6-month maturity. Similarly, the highest price does not coincide with the lowest yield because it was obtained at an auction of T-bills with 12-month maturity.

37 A cover ratio of 1 was recorded for the first time at the auction on 4 May 1999 and for the last time at the auction on 24 August 2010.

38 The cover ratio is closely tracked by debt managers and investors and is one of the most commonly reported statistics in the financial press. Building on sovereign debt auctions in the euro area, Beetsma, Giuliadori, Hanson and de Jong (2020) found that the secondary market yield on the same maturity instrument, past domestic and foreign cover ratios as well as the number of primary dealers exert a positive effect on the current cover ratio while the opposite holds for supply and volatility of yields.

Table 2: SUMMARY RESULTS PER YEAR

	Total bids (million CHF)	Standard deviation	Sum of allotted bids (million CHF)	Standard deviation	Cover ratio	Standard deviation of cover ratio	Average yield (percent)	Standard deviation
1979	1,727.50	159.313	815.50	94.643	2.225	0.657	2.366	1.127
1980	5,634.50	61.445	2,430.00	6.198	2.318	0.358	5.091	0.669
1981	5,238.00	68.821	2,515.50	8.919	2.277	0.281	7.703	1.176
1982	n/a	n/a	2,595.40	17.339	n/a	n/a	3.733	1.543
1983	n/a	n/a	2,598.70	23.442	n/a	n/a	3.011	0.525
1984	n/a	n/a	2,507.60	20.286	n/a	n/a	3.528	0.559
1985	n/a	n/a	2,474.00	39.343	n/a	n/a	4.089	0.398
1986	n/a	n/a	2,592.40	38.635	n/a	n/a	3.813	1.145
1987	n/a	n/a	2,172.45	28.641	n/a	n/a	3.195	0.309
1988	3,393.25	88.950	2,417.15	13.975	1.399	0.409	2.960	0.937
1989	n/a	n/a	2,724.77	23.050	n/a	n/a	6.591	0.681
1990	7,561.95	101.980	4,960.05	48.169	1.629	0.954	8.167	0.478
1991	6,809.30	87.565	5,488.55	56.460	1.237	0.218	7.723	0.234
1992	23,783.25	667.633	15,629.60	313.308	1.439	0.407	7.771	1.014
1993	59,025.50	545.782	34,529.45	308.172	1.735	0.295	4.690	0.457
1994	71,761.20	360.737	46,690.80	247.060	1.564	0.301	4.002	0.176
1995	96,791.55	361.473	47,116.95	158.417	2.081	0.377	2.881	0.717
1996	103,122.80	478.851	49,905.80	157.940	2.085	0.490	1.778	0.364
1997	89,092.35	439.705	49,833.05	158.588	1.791	0.412	1.467	0.197
1998	89,380.15	601.611	45,103.75	128.782	1.990	0.753	1.304	0.294
1999	75,694.05	564.678	46,832.65	226.217	1.593	0.431	1.210	0.372
2000	63,711.55	373.652	43,084.55	241.075	1.514	0.361	2.938	0.516
2001	52,725.15	324.659	39,691.85	263.012	1.361	0.210	2.712	0.534
2002	54,700.90	426.547	40,561.35	285.452	1.351	0.280	0.981	0.477
2003	57,083.10	434.329	39,475.10	218.724	1.448	0.389	0.172	0.088
2004	41,845.30	253.801	39,479.50	242.116	1.069	0.098	0.386	0.220
2005	98,838.20	599.691	51,944.20	235.837	1.944	0.622	0.728	0.096
2006	87,412.65	531.971	47,329.15	206.124	1.843	0.394	1.377	0.282
2007	52,981.35	314.004	33,430.30	205.000	1.654	0.550	2.184	0.229
2008	56,099.70	563.853	36,022.20	319.833	1.605	0.607	1.258	0.782
2009	94,082.35	824.162	36,335.30	332.776	2.916	1.546	0.004	0.022
2010	76,704.80	1,021.963	33,707.95	237.782	2.277	1.385	0.023	0.044
2011	108,763.05	2,655.283	33,358.65	193.412	3.389	4.493	-0.120	0.305
2012	195,055.50	1,199.652	45,739.60	305.323	4.480	1.500	-0.307	0.227
2013	237,152.05	1,115.143	41,711.25	174.786	5.859	1.569	-0.102	0.026
2014	173,197.25	973.499	34,663.10	151.558	5.218	1.812	-0.115	0.063
2015	123,690.90	1,718.418	24,026.00	195.160	5.023	1.975	-1.003	0.204
2016	140,478.45	915.465	23,391.25	93.532	6.149	2.167	-0.994	0.117
2017	128,681.45	600.613	25,309.60	74.499	5.055	1.100	-0.921	0.070
2018	83,841.10	425.991	18,700.65	110.221	4.930	2.204	-0.881	0.053
2019	107,553.90	498.332	20,908.00	116.777	5.684	2.495	-0.837	0.073
2020	198,275.55	687.313	40,518.80	236.043	5.200	1.245	-0.756	0.047
			1,121,322.50	156.1			1.38	2.25

Table 2: Annual averages and standard deviations of auction results. The yellow minimum and red maximum values are based on datasets 1 and 3. n/a: missing values. The sum of bids for 1981 excludes the auction on 15 September (series 1.24), for which the bids are missing.

- (v) A detailed analysis of dataset 1 further shows that of a total of 1,634 auctions, 1,397, or 85 percent, had a maturity of three months, 178 (11 percent) carried a maturity of six months, and 57 (3 percent) had a maturity of 12 months. In two auctions, bills carrying a maturity of one month were offered.

Table 2 presents the main results broken down by year. Maximum values are marked in red, and minimum values are marked in yellow. Bid volumes exhibited large variations from year to year. The minimum bid sum in a year varied from CHF 3.4 billion³⁹ to CHF 237.2 billion with a standard deviation from CHF 64.2 million to CHF 2.7 billion. Allotted volumes (auction sizes) also displayed large variation, ranging from a minimum of CHF 2.2 billion to a maximum of CHF 51.9 billion and a standard deviation between 6.5 million and 336 million.⁴⁰ The cover ratio exhibited an upward trend after 2008, ranging from 1.1 to 6.1 with a standard deviation between 0.1 and 4.4. Yields trended downwards after 1990, coinciding with increasing allocation. This suggests continuous high demand for T-bills, corroborated by high bid volumes at negative yields after 2011. Average (nominal) yields in a year varied between minus 1 percent and 8.2 percent. We further infer from the table that the standard deviation of bids exceeded the standard deviation of auction size.

5.2 Dataset 2

Dataset 2 covers electronic auctions. From the first auction on 27 February 2001 until 29 December 2020, which marks the end of our sample of observations, the SNB conducted 1,035 auctions. This is equivalent to 63.3 percent of all auctions. Hence, in the last 20 years, the number of auctions increased considerably compared with the first two decades. Dataset 2 provides information on single bids, auction date, issuance date, time of bid submission, maturity in days, bid volume, price of competitive bids, value of noncompetitive bids, status of a bid – which can be taken, partially matched, rejected or deleted by the sender⁴¹ – allotted volume, and market-clearing price. In contrast to dataset 1, dataset 2 comprises not only the bid volume but also the number of bids submitted per bidder in relation to those considered as well as direct bidders' identity.

5.3 Dataset 3

Dataset 3 is made up of information available in the SNB's archive in paper format and covers the first 15 years under phone bidding from 19 July 1979 until 1 November 1994. It provides valuable details of developments that are available only at the aggregate level in dataset 1. The minimum information available for each auction can be found in the SNB's press releases, which disclose the serial number, price, yield, total volume issued and volume of noncompetitive bids. In addition, the records include a list of accepted bids for most of the auctions conducted in this period. For some auctions, particularly those before September 1989, the full list of bids – accepted as well as rejected – is also available.

39 In 1979, the sum of bids was lower, but only three auctions were held.

40 The lowest sum awarded in a year was in 1979 with CHF 815.5 million, but the same caveat applies as in the previous footnote.

41 In the aggregation, bids "rejected by sender" were not considered.

Two types of bidders can be distinguished: institutional bidders and natural persons. A total of 1,990 different bidders were identified, of which 1,047 were institutional bidders (52.6 percent) and 943 were natural persons (47.4 percent). The bulk of bids submitted by natural persons came in as noncompetitive tenders ranging from CHF 50,000 to CHF 1 million.⁴² Dataset 3 contains two auctions not exhibited in dataset 1, namely, auction series 3.01 and 3.02. According to internal SNB communication documents, these two auctions seem to have taken place. They represent the first two auctions for T-bills with a maturity of six months. After auction series 3.02, the authorities refrained from further issues of 6-month maturities.⁴³ According to dataset 1, issuance of 6-month maturities resumed on 20 March 1990 (series 3.290). Since then, this maturity line has been offered once per quarter.⁴⁴ Dataset 3 also includes other valuable information, mainly press articles that reflect the views of market participants and commentators in “real time”. Due to the incompleteness of dataset 3, a detailed analysis of the period under phone bidding is not feasible. However, dataset 3 includes information that complements datasets 1 and 2 in terms of the number of bids per auction, price distribution, bid volume, and noncompetitive bidding and enables us to trace the evolution of auction rules.

6. Auction rules

According to auction theory, bidders’ payoffs and sellers’ expected revenue depend on auction rules (Milgrom, 2021). Over time, the rules that governed Swiss T-bill auctions underwent a few changes. Based on auction prospectuses retrieved from dataset 3, this section describes the institutional setup and its most important amendments. The discussion of procedural changes is organised chronologically and is divided into six distinct periods.

6.1 From July 1979 until September 1986

Duration of the auction process

The auction began with the publication of the auction prospectus in the Swiss Official Gazette of Commerce (“Schweizerisches Handelsamtsblatt”) on the Friday before the auction and lasted an entire week. The prospectus contained information on the approximate amount that the treasury aimed to issue and the conditions and timeline of the auction. Submission forms were made available at the SNB’s premises. Bids could be submitted by post mail, fax, or phone and had to come in no later than noon on the auction day, which was the Tuesday following the publication of the prospectus. Bids submitted by phone were filled in by SNB staff.

42 We assigned natural persons an individual bidder code only if they submitted a competitive bid and summarised noncompetitive bids by private investors in bulk to reduce the effort of recording more than one thousand bidders per auction without gaining further information about bidding behaviour.

43 These two auctions were probably deemed experiments by the treasury and consequently were not included in its dataset.

44 Since our aim was to compile a consistent dataset and given that we assigned higher relevance to dataset 1, we excluded series 3.01 and 3.02 from the analysis.

Frequency and minimum bid size

In the first years, auctions were held monthly. The minimum amount of a bid was set at CHF 500,000, and any amount exceeding the minimum threshold had to be divisible by CHF 500,000.

Participants

Any type of investor was allowed to submit price-quantity offers. However, the minimum bid amount of CHF 500,000 actually constituted a high barrier, essentially precluding private investors from regular participation and favouring banks, public institutions and municipal administrations. Initially, participation was restricted to Swiss-based bidders. With series 1.07 in April 1980, auctions were opened to foreign central banks and monetary institutions (Der Bund, 1980). From series 1.15 in December 1980, foreign-based investors in addition to central banks were allowed to participate in the auctions with the special requirement of applying to bidders not considered a bank according to their local regulation to deposit an amount corresponding to their bids at the SNB. This measure was intended to minimise the risk of void bids rather than to discriminate against foreign participants.

Series number

As of 21 October 1980, beginning with series number 1.13, auctions have been assigned a series number.

Reduction of minimum bid

Beginning with auction series 1.36 in September 1982, the minimum bid amount accepted was lowered to CHF 100,000, and any amount higher than that was required to be divisible by CHF 100,000. From July 1979 to September 1986, there were no restrictions in terms of amount per bid or the number of bids that a bidder could submit.

Communication of results

After auction closure on Tuesday, the SNB would communicate the bids obtained to the treasury, which, in turn, set the market-clearing price in consultation with the SNB. Successful bidders were informed on Wednesday. The procedure was completed on Thursday by the SNB's allotment of winning bids. Successful bidders were listed in the money market register maintained by the SNB, and the SNB published the auction results in a press release. It listed the auction's series number, price, yield and borrowed sum (and later also the volume of noncompetitive bids). This set of information remained in place up to auction series 1.85 in September 1986.

6.2 From October 1986 until May 1989

Introduction of noncompetitive bids

The most important change distinguishing the period from October 1986 to May 1989 from the preceding period was the introduction of noncompetitive bids. From auction series 1.86 in October 1986, each bidder had the option to submit a quantity bid of up to CHF 1 million without a price indication. Bidders paid the market-clearing price established at the auction with the guarantee of being considered in full.

Reduction of minimum bid

In addition to the introduction of noncompetitive bids, the minimum bid amount was further lowered, from CHF 100,000 to CHF 50,000, and any amount exceeding it was required to be divisible by CHF 50,000.

Extended communication channel

Another novelty that came into effect in October 1986 was the announcement of results on the Reuters monitor in addition to in the SNB press releases.

6.3 From June 1989 until August 1991

Extension of the auction process

T-bills were attracting growing public attention at the end of the 1980s. To address this increased popularity, beginning with auction series 1.118 in June 1989, the auction day was postponed from Tuesday to Thursday. Since the prospectus was still published on Friday, the submission period was actually extended from two days to almost one week.

Additional information and extension of auction duration

As another measure to address the increase in public demand, submission forms were no longer only available on the SNB's premises but also at its agencies.⁴⁵ In addition, the submission form came with a supplementary sheet that provided further information to bidders. It included information about the submission of noncompetitive bids, the determination of the price based on the yield for competitive bids, the completion of the submission form, and the auction process generally. Bidders could hand in their submission forms at the SNB, one of its agencies, or their bank. Submission forms were still required to arrive at the SNB before noon of the auction day. Successful bidders would be informed about the result on the Monday following the auction day with issuance the following Thursday. As a result, the auction process was extended from one week to two weeks.

Increase in auction frequency

In October 1989, the auctions' frequency was increased from monthly to biweekly, arguably to cope with increasing funding needs and investor demand.

Money market register

In November 1990, the SNB appointed the Swiss Securities Giro SA (SEGA, today SIX) to maintain the money market register that it had previously administered itself. Banks listed in the primary register had to keep a subregister for their own and their customers' T-bills. Creditors other than banks would be listed in the subregister of the bank from which they obtained the T-bill.

⁴⁵ Agencies are cash desks that operate on behalf of the SNB and Cantonal Banks. They are responsible for the issuance and redemption of cash but have limited capacity to store and proceed cash.

Right to cancellation

An important amendment to the auction procedure was introduced in November 1990, giving the treasury the right to cancel an auction after bids had come in.

Additional communication channels

From January 1991, the auction results were made available on Telerate and Investdata in addition to Reuters and the SNB's press release.

6.4 From January 1993 until November 1994⁴⁶

Shortening of the auction process

In January 1993, the auction day was moved back by two days, from Thursday to Tuesday, and the submission deadline was moved forward by one hour to 11 am.

Access to the auction

Another change implemented in January 1993 concerned noncompetitive bids.⁴⁷ Although the maximum amount per bidder was kept at CHF 1 million, aggregates of noncompetitive bids were now submitted. This followed technical changes implemented by the SNB, which would only accept bids from holders with a sight deposit at the SNB.⁴⁸ This technical change implied that natural persons no longer had direct access to the auctions and had to submit their bids via a Swiss-based bank.

Cessation of target volume

A further and arguably more important amendment to the auction procedure that took effect in January 1993 eliminated the advance announcement of the target volume that the treasury aimed to raise.⁴⁹ This practice differs from those of other countries such as Belgium, France, Germany, and Italy, which announce either the auctioned bonds' volume or their target ranges in advance (Beetsma, Giuliadori, Hanson and de Jong, 2018), or the US (Driessen, 2022).

Further increase in auction frequency

Another refinement of the procedure came in January 1994 when the treasury further increased the auction frequency from bimonthly to weekly. This coincided with the tightening of the Confederation's financial situation.

46 Prospectuses between September 1991 and December 1992 are missing in the SNB's archive. For this period we have no information relating to the auction procedure.

47 Since no data are available from September 1991 until December 1992, we assume that this change occurred in January 1993.

48 Swiss banks and Swiss branches of foreign banks, securities dealers, "Pfandbriefzentralen", social security compensation funds, processors of cash, selected fintech corporations, Swiss insurance and Swiss branches of foreign insurance, funds, SICAVs, SICAFs, limited partnerships for collective capital investments, institutions of the financial market infrastructure, institutions of the Federal Administration and others (SNB, 2019).

49 Back and Zender (2001) argued that a uniform-price auction with a fixed supply performs worse from the seller's perspective than one in which the supply may be restricted ex-post.

6.5 From December 1994 until February 2001

The prospectuses available in the SNB's archive end with auction series 6.254 on 1 November 1994. After that, information relating to the auction procedure is missing until January 2001.⁵⁰

6.6 From February 2001 until today

The most significant technical change to the auction procedure was the introduction of electronic bidding via the Eurex Repo platform in February 2001 and since May 2014 on the SIX Repo trading platform. Electronic bidding replaced bidding by mail, phone or fax. Since then, institutional bidders with an SNB account and access to the Eurex Repo platform have been able to submit their bids at weekly auctions between 9.30 am and 11.00 am on the auction day, which has been Tuesday. Private investors are still required to submit their bids via a Swiss-based bank or a foreign bank that meets the aforementioned requirements.⁵¹ The minimum amount is still CHF 50,000. The lag between auction closure and announcement of results was cut to a few minutes, which increased market efficiency and provided a more rational settlement of transactions (Thomann, 2002). As opposed to the preceding subsections, we do not have prospectuses for every auction from February 2001 until today. Therefore, we have based our description of the auction procedure on the terms of issues currently in place and by tapping additional data sources.

Cut of bids at the market-clearing price

Until September 2008, paragraph 5 of the auction prospectus stated that the allocation would be made for all bids considered uniformly at the issue price. Tenders without any price indication (noncompetitive bids) would be taken into account at the issue price. On 3 October 2008, the treasury stated that it would adapt its allocation practice (EFV, 2008a). Paragraph 5 specifies that the treasury reserves the right to proportionately cut awards in case offers exceed the Confederation's funding needs. This provides the treasury with the flexibility to better align auction results to its financial requirements. This change was implemented at the auction of 7 October 2008 (series 3.981). However, as can be inferred from the data, cuts had already been made to the market-clearing price. Therefore, this represented more of a clarification of the auction rule than a novelty.

Rationing of noncompetitive bids

The change in the auction rule announced on 3 October 2008 also changed the treatment of noncompetitive bids. Since their introduction, noncompetitive tenders have been fully allocated with guarantees. While the treasury has continued to accept

50 We searched for any changes to the auction rules from 1992 to 2000 in the treasury's annual reports but did not find any relating to T-bills. According to Thomann (1995), the subscription period was shortened in 1994 by one day, and auction results were announced one hour after auction closing and not the following day. This refinement applied to bond auctions. Whether it also applied to T-bill auctions cannot be determined.

51 With a few restrictions concerning the US, European Economic Area and United Kingdom (EFV, 2020).

noncompetitive bids without limitation at the market-clearing price, since the auction of 7 October 2008, it reserves the right to cut the allocation of noncompetitive bids if offers far exceed its financing needs.

Change in treatment of bids at par

Until August 2011, the treasury classified bids at a price of 100 as noncompetitive. With the auction of 23 August 2011 (series 6.7928), it started considering bids with a price of 100 as competitive. This change was the result of the negative interest rate environment that materialised in August 2011, making competitive bids at a price of 100 the norm.

Cancellation of price ceiling

Owing to the developments and distortions in the money market, in August 2011, the treasury also cancelled the previously applicable upper price limit of 100 percent. Since the auction of 16 August 2011, bids exceeding 100 percent have been accepted. Noncompetitive offers have been considered at an allocation price above par. The two changes implemented in August 2011 strongly affected bidding behaviour.

Communication of results

Auction results are now available on the Eurex Repo platform immediately after allotment of winning bids. Subsequently, this information is also published on Reuters and Bloomberg as well as on the websites of the treasury and the SNB.

7. Analysis

Due to the different characteristics of the three datasets, the evolution of T-bill auctions can be examined from different perspectives. In this section, we study how the changes in auction procedures are reflected in the data on the one hand and how developments in bidding behaviour led to changes in the auction rules on the other hand.

7.1 Overview

Chart 2 visualises the 40-year history of Swiss T-bill auctions by total bid volumes (light grey), volumes issued (dark grey) and yields (blue) together with the most relevant amendments to auction rules discussed in the previous section.

Both bid and issued volumes increased in the mid-1980s. This is arguably attributable to the introduction of noncompetitive bids and the reduction of the minimum bid amount. Both changes resulted gradually in a soaring number of bids by the broad public. The enhanced interest in T-bills also benefitted from the rise in interest rates. The May 1989 auction closed with a yield of 7.54 percent, which was the highest yield since December 1981. With annual inflation running at 2.80 percent, safe short-term T-bills looked attractive compared to time deposits or fiduciary deposits in the Euromarket (Der Bund, 1989).

Chart 2: T-BILL AUCTION RESULTS AND MAIN RULE CHANGES

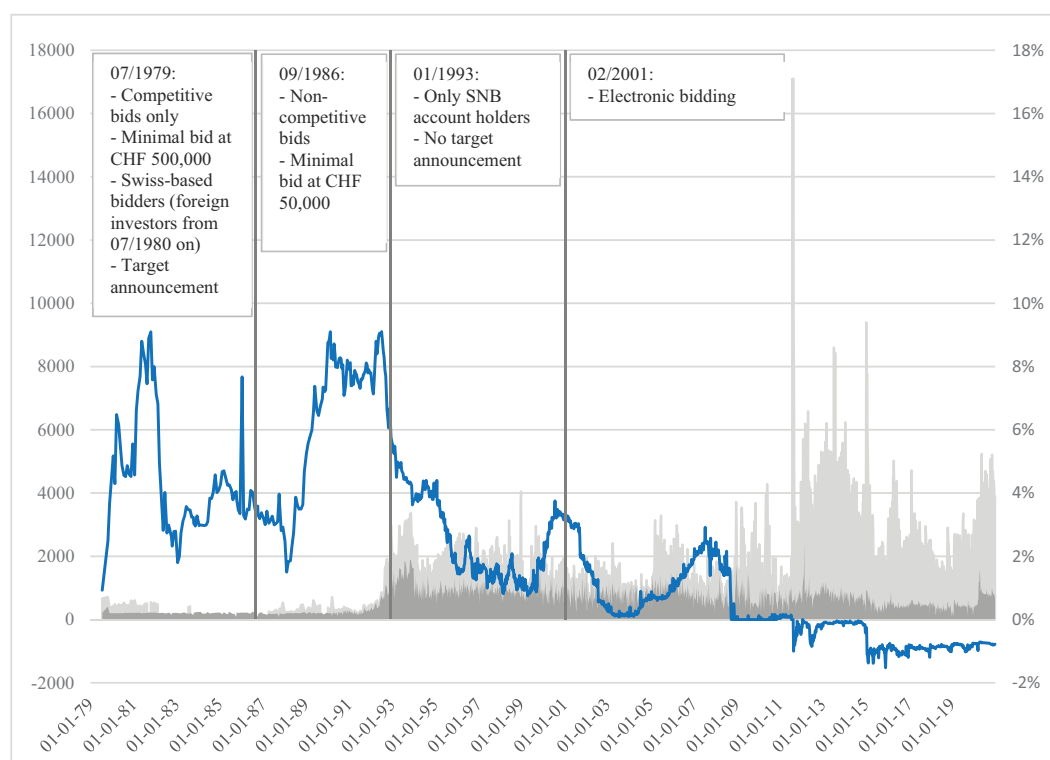


Chart 2: Total bid volume (light grey) and issued volume (dark grey) in million CHF. The blue line (right-hand scale, RHS) shows the evolution of yields in percent. The vertical lines indicate major amendments to auction rules.

Chart 2 also illustrates that in the first decade, T-bill auctions provided much less funding than in the following three decades. Due to low fiscal pressure, auctions were held less frequently in the first decade than in the following decades. The total volume until 30 November 1989 amounted to CHF 25,843.47 million. This corresponds to only 2 percent of total T-bill borrowing until the end of December 2020.

7.2 Falling nominal yields

The last three decades have been marked by a steady fall in yields. As the Confederation's funding requirement has declined steadily in recent years while investing liquidity has climbed to new highs, the treasury has been increasingly restrictive in its allocations. Prices have thus risen, and yields for investors have mirrored this by falling. As can be inferred from Chart 2, the nominal yield was at its all-time high of 9 percent at the beginning of the 1980s. Another spike is observable at the beginning of the 1990s. After peaking in the early 1990s, yields declined continuously, touching the zero line on 7 October 2008 (series 3.981), three weeks after the collapse of Lehman Brothers. After that, the auctions closed at a zero yield (with few exceptions) until the auction on 16 November 2010 (series 3.7888).⁵² In April and May 2010, the escalation of the European sovereign debt crisis and an

⁵² Details are specified in the Online Annex.

Chart 3: DISTRIBUTION OF COVER RATIOS

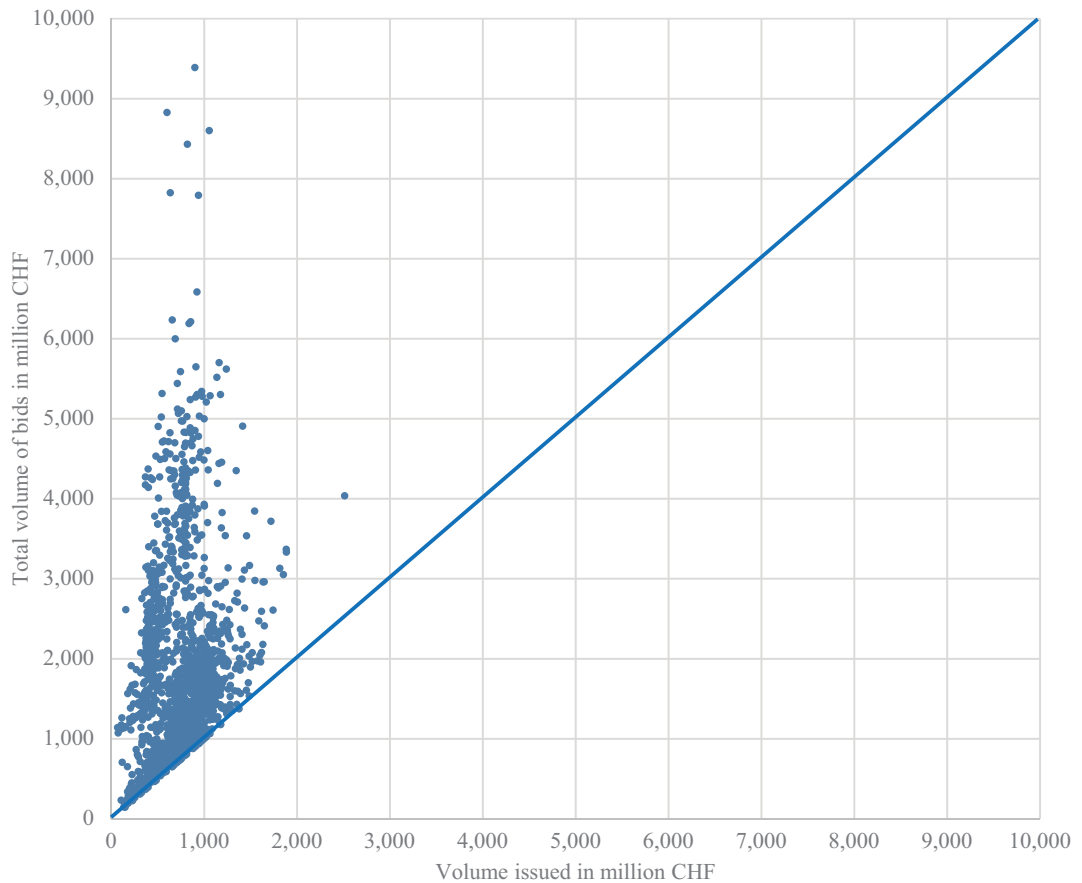


Chart 3: Distribution of cover ratios based on dataset 1. All the observations lie above the 45-degree line.

associated renewal of financial market tensions exerted substantial upwards pressure on the Swiss franc, and the demand for T-bills experienced a boost. This was mirrored by an increase in bids at par or without price, with bids at par exceeding CHF 3 billion, prompting the treasury to also cut bids with zero yield. The subsequent auctions posted a slightly positive yield again, but beginning with the auction of 19 July 2011 (series 3.7923), yields again fell to zero. After the auction on 23 August 2011 (series 6.7928), yields were negative throughout.⁵³ One interpretation of this result is in line with the safe assets literature, according to which short-term sovereign securities offer convenience benefits, particularly safety and liquidity services. The convenience yield may arguably be one (additional) factor explaining the prolonged period of low interest rates on T-bills.

7.3 Cover ratio

Since January 1990, bids totalling approximately CHF 2.9 trillion (CHF 2,855,896 million) were tendered from which CHF 1.1 trillion (CHF 1,095,479 million) were allotted. This corresponds to a cover ratio of 2.91. Chart 3 displays the

⁵³ One exception is the auction on 24 January 2012 (series 3.7950) whose yield was set at 0 percent.

distribution of cover ratios. The abscissa refers to the amount allotted and the ordinate to bids. For reasons of visibility, the range of bid sizes was restricted to CHF 10 billion. The auction of 16 August 2011 is excluded from the chart because it represents a blatant outlier, as explained above. As the chart makes clear, all auctions are (well) covered. No observation lies below the 45-degree line. However, while the cover ratio is an important metric in practice and in empirical work, it should not be overemphasised in the Swiss context. This is because the treasury pursues a (variable) yield objective when deciding on the cut-off price rather than a specific quantitative target for the cover ratio.

7.4 Target volume

From 19 July 1979 to 20 August 1991, the treasury announced the approximate volume that it aimed to raise. This practice was pursued in 159 auctions. Chart 4 illustrates the target volume (blue line) compared with the issued volume (shaded surface) of T-bills with 3-month maturity. The typical target was set at CHF 200 million. Exceptions were the auction on 23 October 1979 (series 1.02), whose target volume was CHF 400 million, and in 1987, when the target volume was fixed at CHF 150 million. The target volume sums up to CHF 31,400 million with an average of CHF 197.48 million per auction. Comparing this with an actual size of CHF 32,598.81 million results in an average auction size of CHF 205.02 million. This means that there was a systematic over-issuance of approximately CHF 8 million on average. In the two auctions of one-month bills conducted on 5 October 1982 (series 4.01)

Chart 4: VOLUME ANNOUNCED VERSUS VOLUME ISSUED

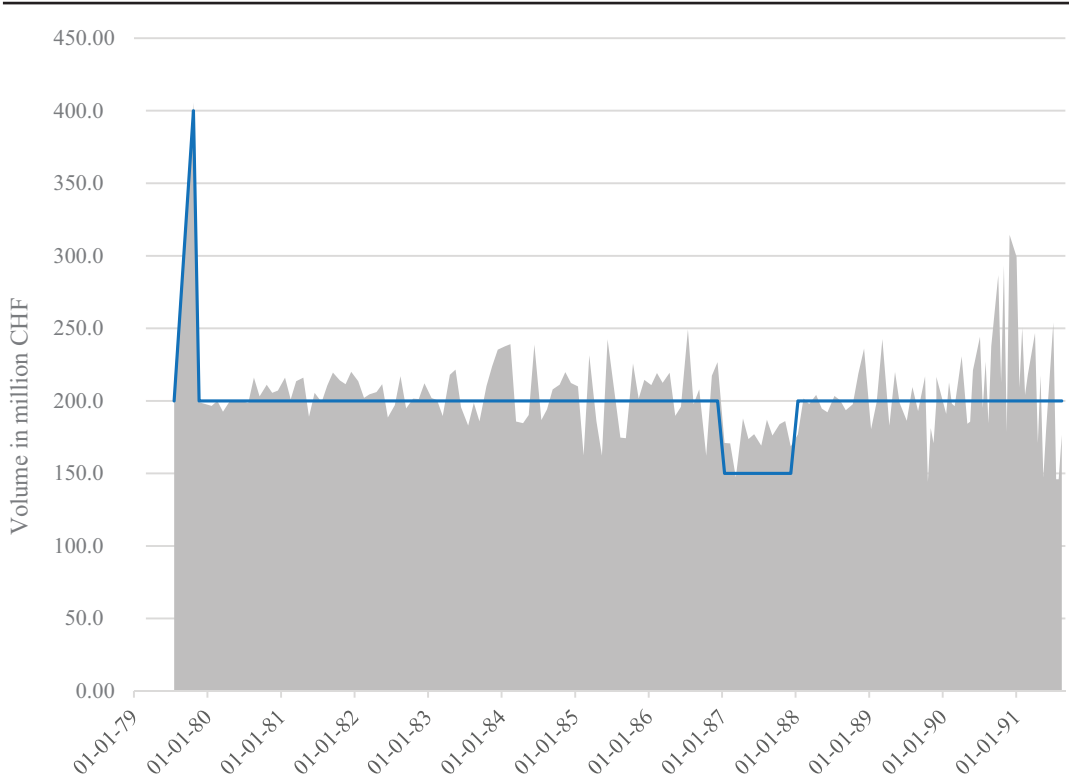


Chart 4: Announced (blue line) and actual volume (grey area) of 3-month T-bills from 19 July 1979 to 20 August 1991 based on dataset 3.

and 11 October 1983 (series 1.49), the target was CHF 150 million, and for the three auctions of 12-month maturity bills (on 8 October 1985, 7 October 1986, and 6 October 1987, series 5.01 to 5.03), it was fixed at CHF 100 million.

Debt managers may choose to cut the allotted volume if the bid volume is lower than expected. However, by reducing the allocation when demand is low, the cover ratio is blown up artificially. This potential endogeneity effect can be corrected by relating the total amount bid to the announced target volume. The result is what Beetsma, Giuliadori, Hanson and de Jong (2020) call the “ex-ante cover ratio”. The data on targeted volumes provided by dataset 3 allowed us to calculate the ex-ante cover ratio. However, we only have data on the total bid amount for 62 auctions. For these auctions, the average ex-ante cover ratio was 2.00. Only in the auction of 6 October 1987 (series 5.03) was it below one. This means that there was undersubscription (bids of CHF 85.60) with respect to the announced target of CHF 100 million. Eventually, CHF 74.60 million was allocated, implying an (ex-post) cover ratio of 1.15.

We lack information about the exact day that the treasury stopped communicating a target volume. The last auction in dataset 3, which exhibited an announced target volume, was on 20 August 1991 (series 1.160), while the first auction in which the issued volume was determined by incoming bids without a preceding target volume was on 5 January 1993 (series 3.187). Based on the volume issued contained in dataset 1, this announcement policy seems to have been discontinued between August 1991 and 7 July 1992 (series 1.177) at the latest, concomitant with a sharp increase in the auction’s size to CHF 772.3 million. In April 1992, the treasury started providing an issuance calendar for bond auctions, realising the benefits of predictability in an environment of large deficits.⁵⁴ The earliest issuance calendar for T-bill auctions included in dataset 3 suggests 27 August 1993. However, it is likely that the calendar for bills coincided with the publication of the calendar for bonds.

Two factors may have led to the discontinuation of target announcements. The first is the increase in demand for T-bills since 1989, which may have called for more flexibility to address the change in demand. The second potential factor was the sharp rise in funding requirements in the early 1990s. Predicting market outcomes arguably became more difficult. Announcing a target that had become more difficult to reach would risk increasing the uncertainty among investors and tarnishing the treasury’s reputation.

7.5 Noncompetitive bids

The next results relate to noncompetitive bids, which are summarised in Table 3. The average noncompetitive tender amounts to CHF 334.10 million with a standard deviation of CHF 596.46 million. The aggregate volume totals CHF 515,847.65 million

54 Cf. Ranaldo and Rossi (2016). A strategy of regular, pre-announced issuances makes debt management predictable and contributes to liquid debt markets in which investors can trade continuously at low transaction costs. Garbade (2015) described how the US Treasury manages to maintain the reputation of a regular and predictable issuer despite occasionally changing issuance plans in terms of volume, frequency and/or maturity. Dentler and Rossi (2022a,b; 2024) provide a theoretical rationale for over-issuance relative to the announced volume. This topic is underresearched.

Table 3: NONCOMPETITIVE BIDS

	Total	Average	Standard deviation	Minimum	Maximum
Volume submitted (mio. CHF)	515,847.650	334.098	596.457	0.000	17,103.300
% of total bids	18.00	24.00	23.48	0.00	100.00
Volume considered (mio. CHF)	434,440.800	281.374	257.717	0.000	1,718.850
% of bids considered	39.82	37.52	29.49	0.00	100.00

or 18.0 percent of bid volume in an auction. The maximum amount of bids without price quotation in an auction summed up to CHF 17,103 million and was observed in the auction of 16 August 2011. While on average 24.0 percent of bids came in noncompetitive form, 37.5 percent were considered. In terms of borrowed sums, the relevance of noncompetitive tenders is even more compelling, accounting for 39.8 percent of the total. This highlights the importance of noncompetitive bidding as a stable source of funding for the Confederation's short-term financial needs. Noncompetitive tenders are also popular with investors. Only in two auctions (on 1 December 2015, series 3.8151, and 22 December 2017, series 3.8359) have there been no noncompetitive bids.

Chart 5 illustrates the proportion of total bid volume (wine-red), total volume allotted (green) and noncompetitive bid volume (blue) since 1990. For the purpose of visibility, the range of bid volume was again limited to CHF 10 billion. As explained in subsection 6.6, noncompetitive bidders were allotted in full (up to a maximum envisaged by auction rules) until September 2008. Since then, the rules have allowed rationing, a practice pursued in 53 auctions between 7 October 2008 and 4 August 2015, especially during the GFC with the peak in 2009 and the European sovereign debt crisis (December 2008 to August 2011). The auction of 23 August 2011 (series 6.7928) marks a turning point when for the first time no upper limit was imposed on the price, which disciplined bidders again and resulted in noncompetitive bid volumes conspicuously lower than before.

7.6 Swiss National Bank measures

The period subsequent to the GFC and the European sovereign debt crisis was punctuated by several important events, some of which deserve special mention. One was the SNB's introduction of extraordinary measures, which had a direct relationship with the developments in T-bills. On 15 October 2008, the SNB announced that it would issue its own short-term debt certificates (SNB Bills) on a regular basis to absorb Swiss franc liquidity. On 3 June 2010, the SNB issued for the first time Bills whose maturity of 84 days came close to that typically chosen for T-bills.⁵⁵

Even before these events, SNB decisions were relevant to T-bills in addition to determining the level of short-term interest rates. One example was their use on a swap basis to steer the banking system's liquidity beginning in September 1992. With this instrument, short-term movements in banks' sight deposits with the SNB

⁵⁵ As opposed to T-bills, SNB Bills in Swiss francs have been auctioned under the DPA format. For its bills in US dollars, the SNB applied the UPA format.

Chart 5: TOTAL BID VOLUME, NONCOMPETITIVE BIDS AND ALLOCATION

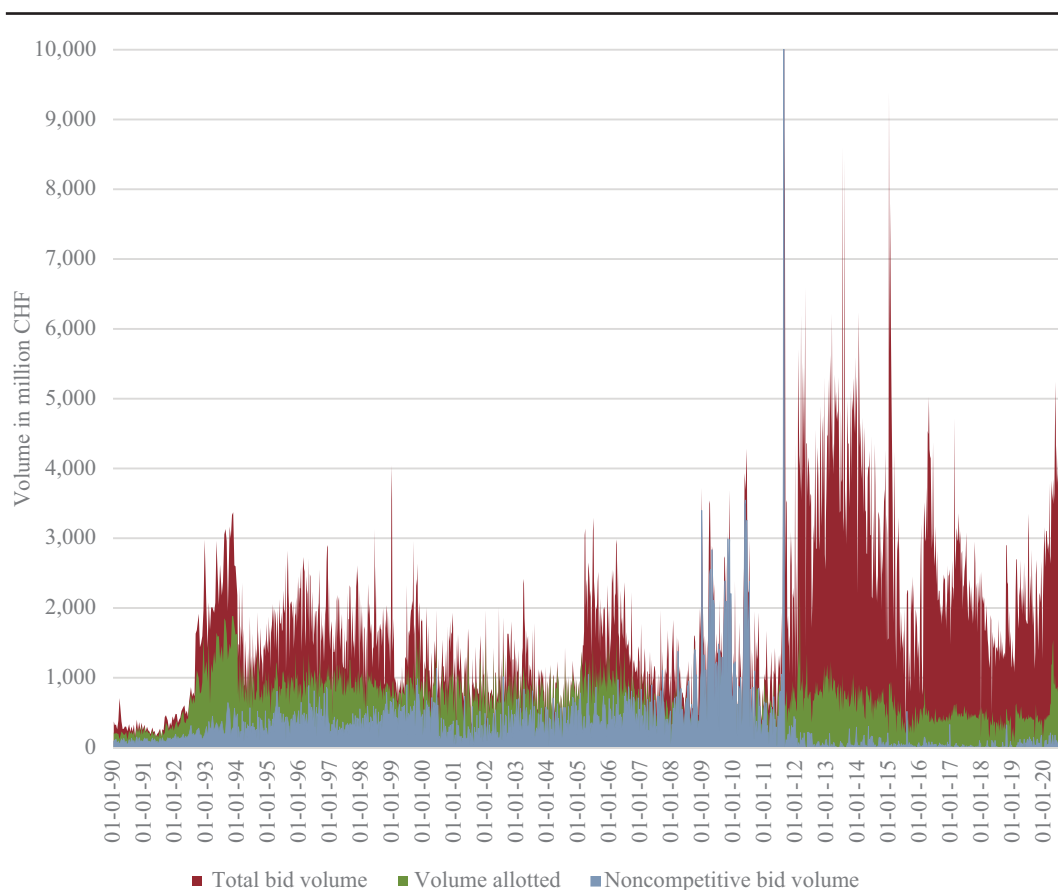


Chart 5: Comparison of noncompetitive bidding with total bid volume and allotted volume based on dataset 1.

could be compensated for with purchases, sales or swaps of T-bills, boosting their attractiveness (Thomann, 1993). The SNB pursued this practice until spring 1998, when it replaced it with repos, which became its main tool to manage liquidity in the financial system. T-bills have since been eligible for repo transactions.

The growing uncertainty fuelled by the European sovereign debt crisis, the discussion on the American debt ceiling and global recession fears led to a rapid appreciation of the Swiss franc, which reached record highs in summer 2011. To comply with its price stability mandate, the SNB was compelled to take a series of countermeasures in August 2011. It reduced the interest range for the 3-month Libor to 0–0.25 percent, refrained from renewing expiring repos and SNB Bills, and repurchased those outstanding. In addition, massive liquidity was injected by means of foreign exchange swaps. In its wake, T-bill yields dropped to zero in July 2011 for the first time since November 2010. The suspension of SNB-Bill auctions triggered an unprecedented demand for T-bills culminating in the auction on 16 August 2011. In addition, a zero yield was no longer market-conform. Only with the admission of bid prices above par introduced at the following auction did rates return to levels compatible with the market. On 6 September 2011, the SNB announced a floor to the euro of CHF 1.20 per euro.

As noted several times, the auction on 16 August 2011 stands out in many respects and marks a turning point in auction outcomes. It not only resulted in a collection of bids of CHF 17.106 billion, a size never seen before or afterwards, but

almost all of them came in without price quotation. A zero interest rate was too high and out of sync with the market. This made T-bills particularly attractive to foreign investors. Furthermore, since bidders knew that the bid price could not be set above par, they faced a simple choice: to either enter 100 or submit a noncompetitive tender. This is the background that prompted the treasury to remove the price ceiling of 100 percent and accept bids above par. As mentioned, bids without price quotation have continued to be considered even if the market-clearing price closes above par. In addition to featuring the highest total bid volume and the highest volume of non-competitive tenders, this auction collected the highest number of bids, totalling 193, with 165 of those made by one single participant, and exhibited by far the highest cover ratio. Beginning with the auction the following week (23 August 2011), T-bills closed at negative yields until the end of our sample in December 2020.

Following unfavourable economic data in the euro area and the introduction of negative interest rates by the ECB in June 2014, the Swiss franc rose against the euro and approached the floor. In mid-December, rapidly escalating uncertainty in the financial markets fuelled further demand for safe investments. On 18 December, the SNB lowered the target range for the 3-month Libor from 0 to 0.25 percent to a level of -0.75 to 0.25 percent and introduced a negative deposit rate for a fraction of banks' sight deposit account balances applicable on 22 January 2015. On 15 January 2015, the SNB discontinued the minimum floor to the euro, lowered the target range for the 3-month Libor by an additional 50 basis points to a level between -1.25 and -0.25 percent and set the interest rate for balances held in its sight deposit accounts to -0.75 percent. The yield on T-bills fell even further into negative territory (cf. Chart 2). The lowest value of -1.521 percent p.a. was recorded at the auction for a T-bill with 3-month maturity on 1 December 2015 (series 3.8151).

Since the removal of the floor to the euro, the yields on T-bills at all maturities were below the rate on banks' sight deposit accounts with the SNB of -0.75 percent until the auction of a 3-month T-bill on 17 March 2020, whose yield was set at -0.983 percent (series 3.4755).⁵⁶ The following auction on 24 March 2020 closed at a yield of -0.75 percent, in line with the SNB's policy rate. Subsequent auctions exhibited yields slightly above -0.75 percent until September 2020. Beginning in October, yields dropped again below this mark and reached a low of -0.809 percent at the auction on 1 December (series 3.4792) 2020. Reflecting the high creditworthiness of the Swiss Confederation as a borrower, T-bill yields were also regularly lower than comparable money market rates, such as Libor or SAR (Swiss average rate).

7.7 Demand

7.7.1 Participation

Dataset 2 allows for a more in-depth analysis of demand. One measure is bid participation. Chart 6 displays the total number of participants (green) compared to winning bidders (blue) together with the development of yields (right-hand scale). The thick horizontal line marks the threshold to negative values.

56 In one instance, the yield of a 12-month T-bill in an auction conducted on 30 December 2019 (series A.8364) reached -0.75 percent.

Chart 6: PARTICIPATION IN ELECTRONIC AUCTIONS

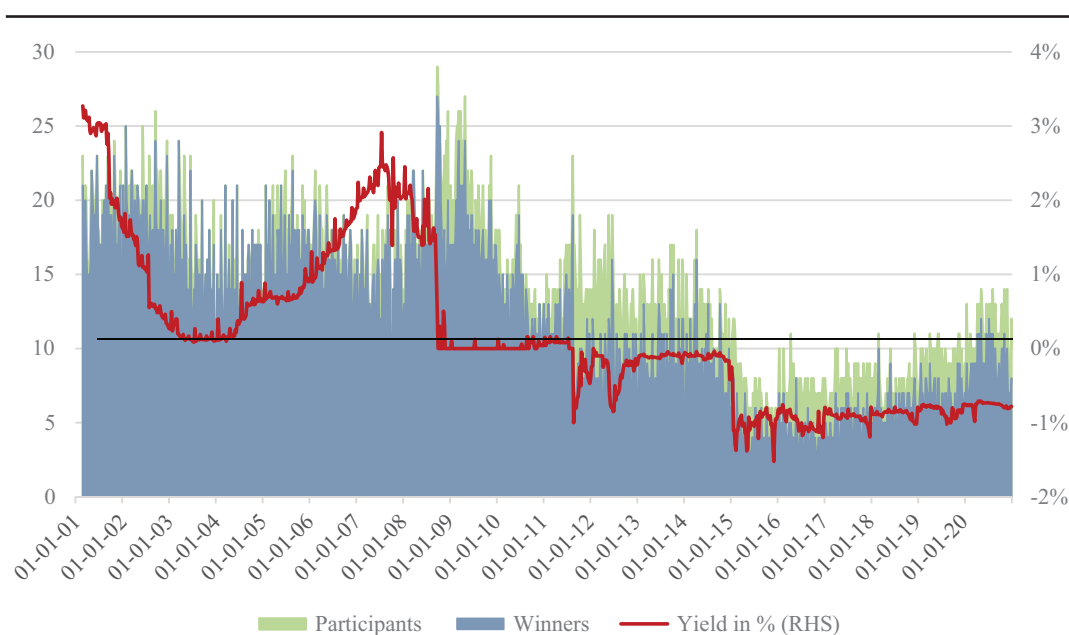


Chart 6: Development of bidders' participation, winners and yields from February 2001 to December 2020 based on dataset 2.

From 2001 to 2008, between 20 and 25 participants bid in the auctions. After a blip in 2009, participation dwindled, reaching its nadir in 2016. Since then, the number of bidders has increased but is still below the levels of 2000–2010. In terms of yields, the average was 0.181 percent, with a maximum of 3.271 percent (auction on 27 February 2001) and a minimum of –1.521 percent (auction on 1 December 2015).

A total of 111 different bidders submitted at least one bid in at least one auction between February 2001 and December 2020. On average, 13 bidders participated in an auction with an average of 11 winners. The lowest participation rate was on 22 December 2017 (series 3.8359), when only one bidder tendered four competitive bids, of which three were accepted. As described above, this is one of two auctions without noncompetitive bidding. The highest participation rate was recorded on 23 September 2008 (series 3.979) during the outbreak of the GFC with 29 bidders.

The number of bidders follows the evolution of yields with a slight delay. When yields turned negative in August 2011, their number dropped and took a second dive after yields plunged in January 2015. While this is an indication of demand restraint and a narrowing of the primary market due to negative interest rates, a moderate recovery of participation can be observed in recent years despite nominal yields hovering below the SNB's policy rate.

Each bidder participated in an average of 122 auctions and was considered with at least one bid in 104 auctions. One bidder never bid successfully, whereas another had at least one winning bid in 922 auctions. However, participation varied greatly. One bidder bid only in one auction, while another submitted bids in 994 auctions, which means a participation rate of 61 percent. On average, each bidder submitted two bids per auction, with a range from one to nine bids, and had an average of one winning bid, with a range of zero to seven.

Chart 7: BID PRICE SPANS, AUCTION PRICES AND UNCERTAINTY

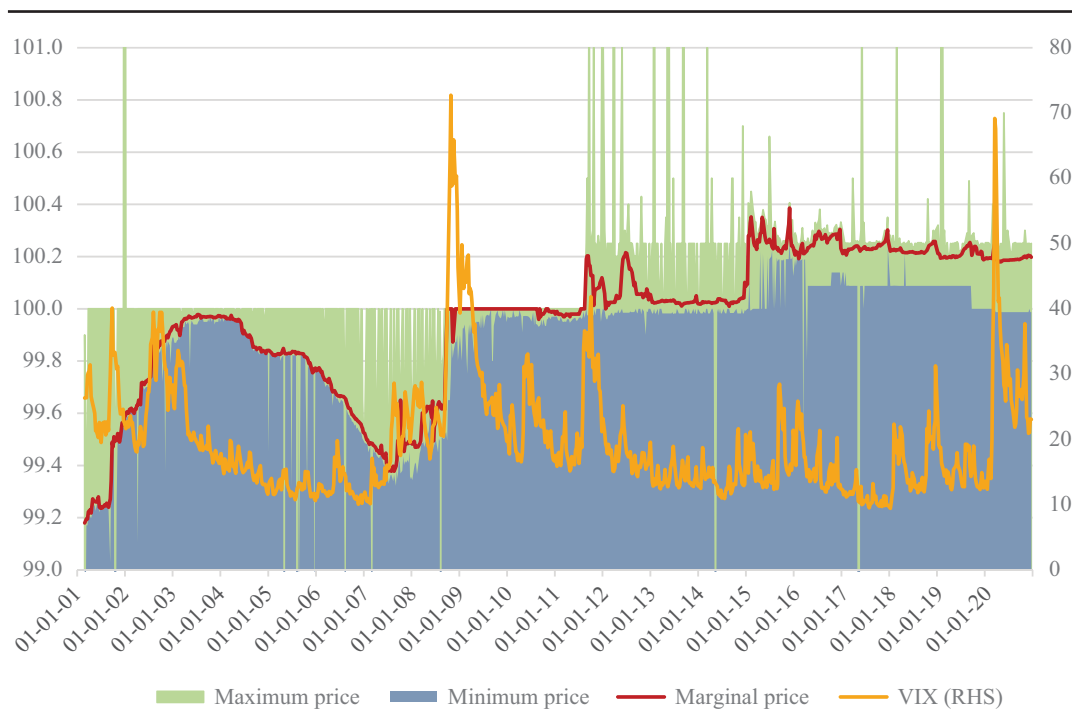


Chart 7: Bid price span of 3-month T-bills from February 2001 to December 2020 based on dataset 2.

7.7.2 Price spans

Chart 7 displays the spans of bids for T-bills with 3-month maturity and the corresponding market-clearing price.⁵⁷ For the purpose of visibility, the range of bid prices is restricted between 99 and 101. The actual dispersion is much wider and ranges between 92.288 (auction on 5 March 2002)⁵⁸ and 105.000 (auction on 27 December 2001). However, bid prices beyond the range shown in Chart 7 were exceptional and represent only 2 percent of observations (21/1035). The average marginal price (winning bid) was 99.939. The highest marginal price was set at 101.025 (auction on 5 July 2016) and the lowest at 97.123 (24 July 2001).

From Chart 7, we can distinguish two phases. In the first, which lasted until summer 2011, the price span was negative in the sense that bids came in below 100 (with one outlier). After that, the bulk of bid prices were above 100 with two exceptions, one on 15 March 2016 (series 3.8166) and the other on 12 April 2016 (series 3.8170). On 19 July 2011 (series 3.7923), the market-clearing price was set at par for the first time and above par on 23 August 2011 (series 6.7928). Since then, the market-clearing price has been above par (yields below zero percent).

Another insight emerging from Chart 7 is that the market-clearing price was mostly at the lower end of the price span until January 2015. Between the auction of 30 December 2014 (series 3.8103) and the next auction of 6 January 2015 (series A.8104), it leaped to 100.2. Starting with the auction of 20 January 2015 (series 3.8106),

⁵⁷ Bid dispersion has been found to be important in both DPAs and UPAs. Cf. Nyborg, Rydqvist, and Sundaresan (2002) and Keloharju, Nyborg, and Rydqvist (2005).

⁵⁸ The lowest bid was in fact 0.450, obviously an erroneous entry.

the market cleared at approximately 100.2. Since then, the market-clearing price has lain at the upper bid price range.

The average price span is 31.6 basis points with a standard deviation of 45.9 basis points. The lowest span was on 1 September 2009 (series 3.7825), in which all bids were either noncompetitive or came in as competitive tenders at par. This implies that all bids were accepted at the price of 100, entailing a span of zero. The widest dispersion below a clearing price of 100 occurred on 3 March 2002 (series 6.637), where the lowest bid was at the mentioned minimum of 92.288, giving rise to a price range of 771 basis points. The widest dispersion at a market-clearing price above 100 was 546 basis points and occurred on 27 December 2001 (series 3.628) when the maximum bid of 105 was submitted. This was the only bid above par until 23 August 2011 (series 6.7928). In the latter auction, the first without a price ceiling of 100, bids totalled CHF 8.829 billion, of which only CHF 904.45 million was without quotation. After 2001, 16,092 competitive bids came in at 100 or above (63.7 percent) and 9,553 below 100 (36.3 percent).

Another notable outlier occurred on 13 May 2014 (series 3.807), featuring the lowest bid at 97.5. This was exceptional because since 23 August 2011 (series 6.7928), the auctions had closed above par, with the lowest bid prices coming very close to par (above 99.8). As mentioned, in two auctions, bid prices exhibited a dispersion from below par to above par, namely, on 15 March and 12 April 2016. From the auction of 19 April 2016 (series 3.8171) until that on 17 March 2020 (series 3.4755), all bids – even the lowest ones – were at least at par. The auction on 24 March 2020 (series 3.4756) was the first in four years in which the lowest bid was below par.

According to auction theory and empirical evidence, intrabidder dispersion, which we simply measure by the price span, should widen when market uncertainty increases. However, as shown in Chart 7, after 2008, there seems to be no association between the price span and the CBOE Volatility Index (VIX), which provides a quantifiable measure of market risk and investors' sentiments. From 2001 to 2008, the price span tightened when uncertainty increased and widened when uncertainty abated. One way to interpret this finding is that there is no evidence of bidders' adjustment to the winner's curse.⁵⁹ Another interpretation relates to the safe assets literature. Accordingly, the tightening of the price span under uncertainty may suggest increased homogeneity of demand for safety reasons.

7.7.3 Bid volume

Chart 2 suggests that since the beginning of the 1990s, a decrease in yields has gone hand in hand with a rise in bid volume, which jumped suddenly in 1992 and remained more or less at the higher level for the next two decades. From 2012, a further step up in bid volume is observable. This is especially noteworthy, as it coincided with the negative yield environment, peaking between 2012 and 2015.

59 The lack of or reduced incentives to lower bids to contain the winner's curse in UPAs compared to in DPAs is consistent with theory. Although Goldreich (2007) reported empirical evidence of underpricing in US UPAs, it was significantly lower than in DPAs. By the same token, Nyborg, Rydqvist, and Sundaresan (2002) showed evidence that bidders in DPAs of Swedish treasury papers reacted to a high level of uncertainty by lowering bid prices and demand while increasing bid dispersion, which is consistent with rational adjustments to the winner's curse.

This development reflects the peculiarity of a short-term security considered a safe haven. The average bid volume amounted to CHF 55.50 million. Chart 2 further shows that allotted volumes exhibit a slight downward trend that reflects restrained allocation by the treasury.

Developments in forex markets had a bearing on auction outcomes.⁶⁰ After an average of CHF 2.4 billion bids were submitted in 2017, the average bid volume fell to CHF 1.6 billion in 2018. This is attributable in part to the fact that the basis swap narrowed significantly over the course of the year, and spreads reached their tightest level since the GFC, making investments in Swiss T-bills less attractive for USD investors in particular.⁶¹ High allocation prices, combined with less favourable conditions on forex markets for foreign investors, caused demand to plunge at the start of 2019. To prevent domestic investors turning away from the auctions altogether, the treasury invested in rebuilding demand by cutting allocation prices. As a result, yields on T-bills were again closer to the SNB policy rate of -0.75 percent. As shown in Table 2, the average yield on T-bills issued in 2019 was -0.84 percent, up from -0.88 percent in 2018. Auction demand picked up again after the decline at the start of the year, with the result that the average of CHF 2.0 billion bids submitted per auction was even higher than that of CHF 1.6 billion of 2018 (Treasury, 2020).

With the outbreak of the COVID-19 pandemic and the entailing fiscal measures, the treasury increased the volume of outstanding T-bills by CHF 8 billion to over CHF 14 billion between mid-March and early July 2020. Despite the high volumes, the average yield was -0.76 percent, compared with -0.84 percent in 2019. With an average of CHF 3.8 billion, demand almost doubled with respect to 2019, with only minor price concessions. This is proof of the absorbing capacity of the Swiss money market.

7.7.4 Number of bids

Another measure of demand in addition to bidders' participation, bid price spans, and bid volumes is the total number of bids. A total of 38,349 offers were presented, and 24,486 were taken by the treasury, which corresponds to 63.8 percent and an average per auction of 65.6 percent. A total of 14,251 bids came in noncompetitive form, which corresponds to 58 percent of winning awards.

Chart 8 displays the number of bids tendered in an auction. As can be inferred from the chart, the number of bids varied dramatically, especially between 2008 and 2015. In the last few years, 20 to 30 bids were submitted in an auction, which marked the lowest level in the last 20 years. Most recently, approximately 40 bids were again posted, similar to the beginning of electronic bidding. While the highest number of bids in a single auction was 193 (auction on 16 August 2011), the second-highest

60 According to the Treasury (2015), the SNB's introduction of negative interest rates bolstered the demand for basis currency swaps and increased the premium. In a basis swap of CHF for foreign currencies (particularly USD), the counterparty (e.g., the USD holder) receives a premium by temporarily buying Swiss francs against US dollars. Therefore, USD investors can still generate a positive return or a higher return relative to an alternative investment in equivalent USD securities, despite investing the temporarily-acquired CHF in T-bills with negative interest.

61 One example of the significance of the basis swap for T-Bill auctions is the widening of the spread to over 40 basis points in October 2018. The total bids rose from approximately CHF 1.3 billion to just under 3 billion and then – in line with the normalisation of the basis swap – fell again to approximately 1.5 billion (Treasury, 2018).

Chart 8: NUMBER OF BIDS PER AUCTION

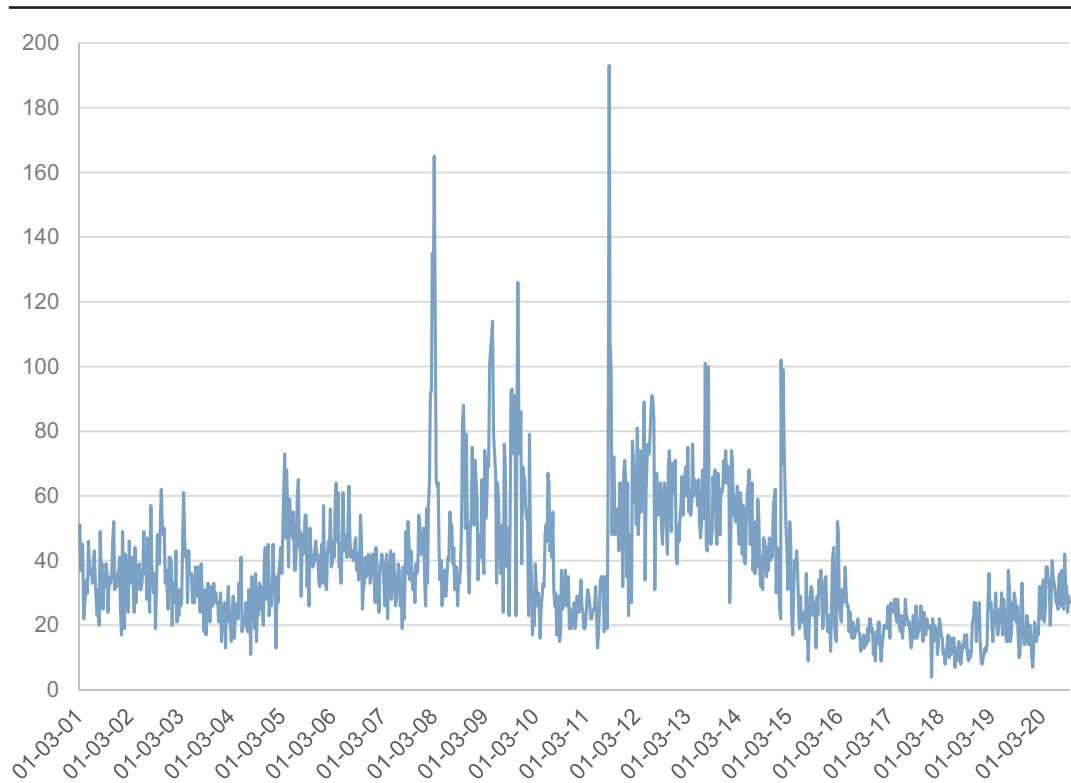


Chart 8: Number of bids per auction from February 2001 to December 2020 based on dataset 2.

spike featured 165 bids (auction on 6 March 2008). The other extreme was the mentioned auction on 22 December 2017, in which just four bids were submitted. On average, 38 bids were posted, 24 of which were allocated.

7.7.5 Main investors

Who were the investors posting the winning bids (awarded quantities) discussed above? Can we observe changes in awarded volumes over time? This subsection summarises the evidence. The identity of investors is related to the safe assets literature. Many Swiss companies need safe, short-term assets to manage their liquidity. If they are banks, they can access repos. However, for corporations, depositing cash in bank accounts may not always be the best option. As explained in section 4.2, these investors may instead invest in T-bills.⁶²

Unfortunately, the identity of end investors cannot be determined at the bidder level over the entire sample period. Only the tenders of direct bidders, which may include bids of indirect bidders, can be identified. While dataset 3 provides detailed identification of bidders (until the end of 1992), it is incomplete. In contrast, while dataset 2, which covers information since the introduction of the electronic bidding system, does not allow for disentangling the identity of end investors, it has the advantage of completeness. For this reason, the analysis in this section is also based on dataset 2.

⁶² Bidders' identity is also key from an auction theoretic perspective because symmetry is an important underlying assumption in theories of multiple-unit common value auctions.

Table 4: SUMMARY OF AWARDS BY BIDDING CATEGORY

Bidders	Number of awards	Sum of awards (CHF)
Big banks	10,718 (43.23 %)	265,698,250,000.00 (38.29 %)
Cantonal banks	3,229 (13.04 %)	130,818,050,000.00 (18.85 %)
Foreign banks	2,190 (8.84 %)	65,011,100,000.00 (9.37 %)
Other banks	8,449 (34.12 %)	229,448,850,000.00 (33.1 %)
Regional banks	168 (0.68 %)	2,918,050,000.00 (0.42 %)
Nonfinancial institutions	11 (0.04 %)	66,000,000.00 (0.01 %)
Total	24,765 (100 %)	693,960,300,000.00 (100 %)

Table 4: Number of awards and the corresponding sum per bidder category and in percent. The sample ranges from February 2001 to December 2020.

Table 5: AVERAGE AWARD SIZE BY MAIN BIDDER CATEGORY

Bidders	CHF
Big banks	24,789,910
Cantonal banks	40,513,487
Foreign banks	29,685,434
Other banks	27,156,924

Table 5: Award size on average per main bidder category. The sample ranges from February 2001 to December 2020.

Direct bidders can be grouped into five categories of banks, which were constructed following the classification adopted by the SNB in its annual report *The Banks in Switzerland* (discontinued in June 2020). The five categories are 1. Cantonal banks, 2. Big banks, 3. Foreign and foreign-dominated banks, 4. Other banks (including private banks, trade banks, exchange banks, small credit banks), and 5. Regional banks (including savings banks and Raiffeisen banks). A last category encompasses the remaining bids, mainly from nonfinancial institutions.

Table 4 gives an overview of awarded volumes by bidding category. Since the switch from phone to electronic bidding, auctions have raised approximately CHF 694 billion. This corresponds to 62 percent of the total since 1979. The two dominant winning bidders are big banks and other banks, which together were allocated CHF 495 billion or 71 percent of the total. Cantonal banks were allocated 19 percent. Regional banks and nonfinancial institutions played only a marginal role in the primary market (0.7 percent of the number of awards and 0.4 percent in terms of allocated sum).⁶³

Table 5 presents the average sizes of allocated volumes by bidder category. Interestingly, the cantonal banks exhibited average awards that stood out with clearly higher average allocation compared with the other three bidder categories, whose average winning volumes were broadly in line with one another.

⁶³ Regional banks showed a strong presence in approximately 2005/2006. Outside this period, they exhibited only rare participation in terms of awarded volumes.

Table 6: AWARDS BELOW CHF 75 MILLION BY MAIN BIDDER CATEGORY

Bidders	Number of awards	Sum of awards (CHF)
Big banks	9,476	130,448,300,000.00
Cantonal banks	2,780	83,060,350,000.00
Foreign banks	1,868	30,307,200,000.00
Other banks	7,280	104,538,450,000.00
Total	21,404	348,354,300,000.00
In percent	86.43	50.20

Table 6: Awards below CHF 75 mio per main bidder category. The sample ranges from February 2001 to December 2020.

Table 7: SUMMARY STATISTICS OF AWARDS FOR MAIN BIDDING CATEGORIES

Summary awards (CHF)		Summary awards per auction (CHF)	
Minimum	50,000.000	Minimum	50,000.000
1st quartile	2,200,000.000	1st quartile	50,000,000.000
Median	10,000,000.000	Median	150,000,000.000
Mean	28,021,817.000	Mean	189,400,000.000
3rd quartile	50,000,000.000	3rd quartile	284,400,000.000
Maximum	500,000,000.000	Maximum	1,561,000,000.000

Table 7: Summary statistics in the aggregate and by auction. The sample ranges between February 2001 and December 2020.

Chart 9: AWARDED VOLUMES OVER TIME PER MAIN BIDDER CATEGORY

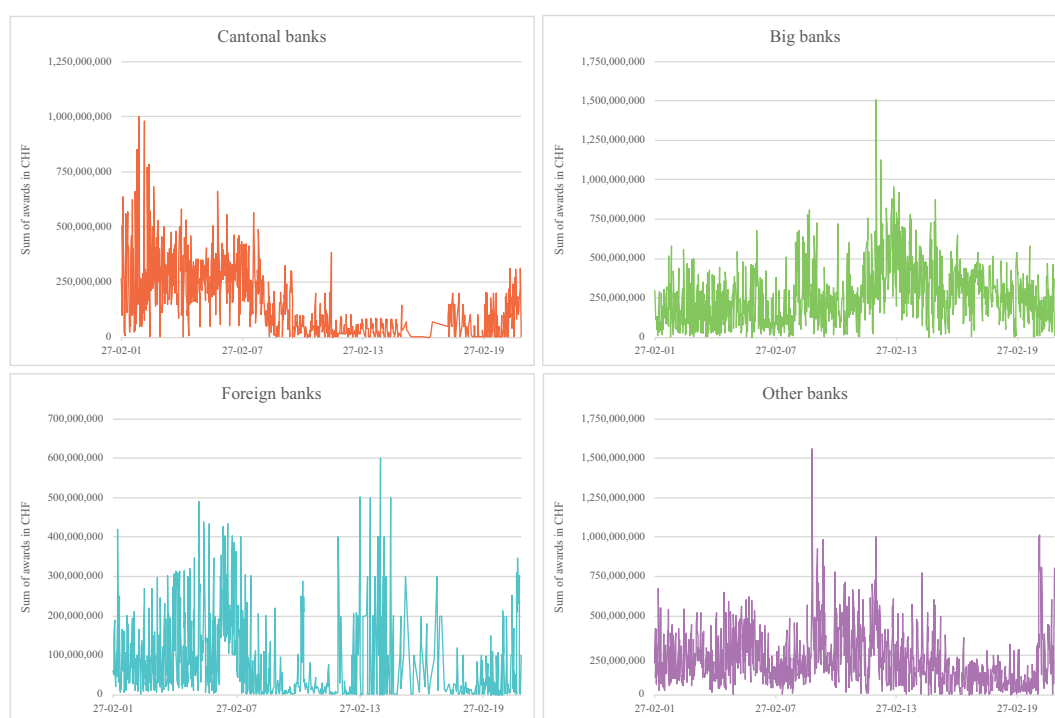


Chart 9: Awards by major bank category. Panel a) Cantonal banks, panel b) Big banks, panel c) Foreign banks, panel d) Other banks. The sample size ranges from February 2001 to December 2020.

Chart 10: DISTRIBUTION OF AWARDS

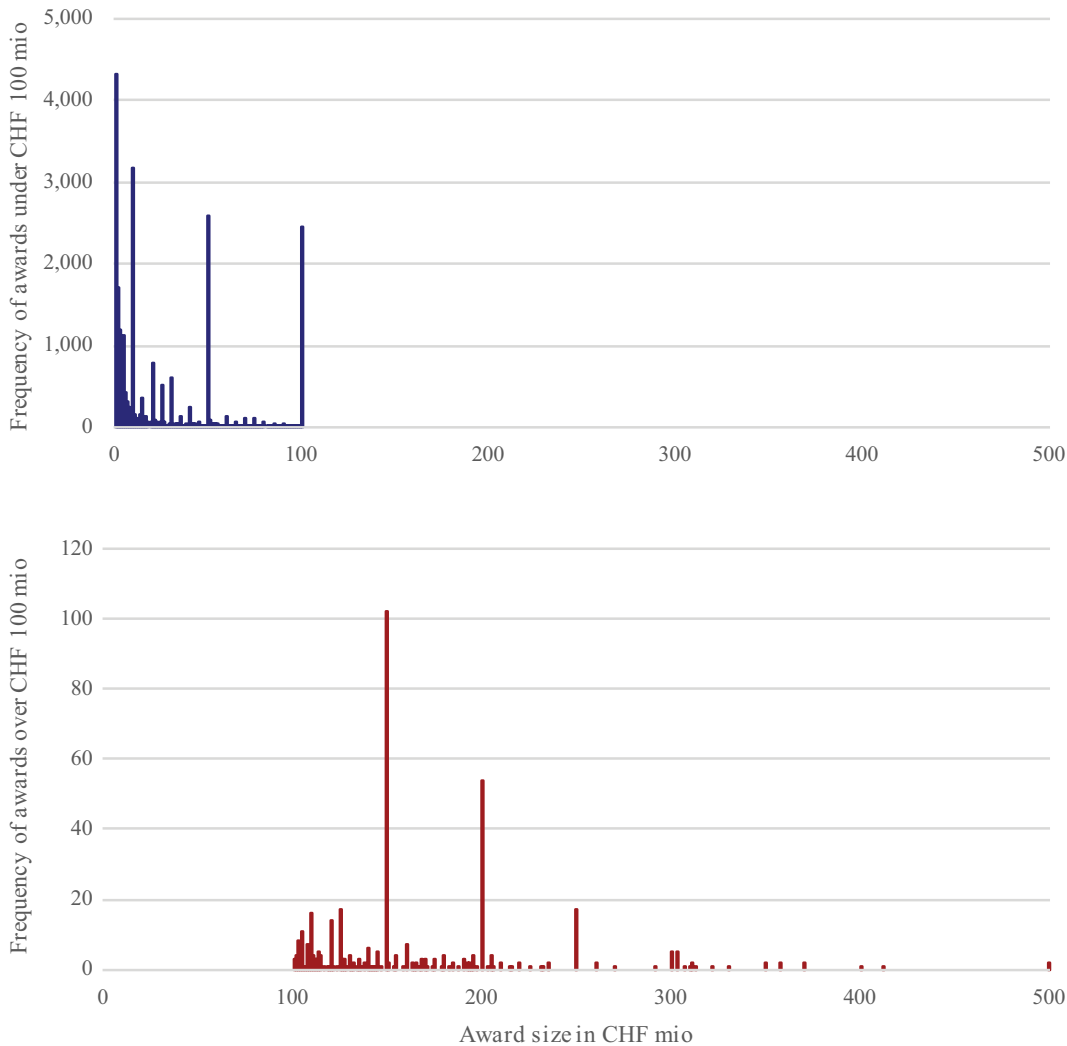


Chart 10: Distribution of awards. Each bin denotes CHF 1 million. The upper panel exhibits 100 bins. The first bin shows allocated volumes between CHF 0 and 1 million, the second between and CHF 1,001,001 and 2 million, the third between CHF 2,001,001 and 3 million, etc. The last bin captures awarded volumes ranging from CHF 99,000,001 to 100 million. The lower panel includes 400 bins. The first bin exhibits awards between CHF 100,000,001 and 101 million, and the last bin shows allocations between CHF 499,000,001 and 500 million. The sample ranges from February 2001 to December 2020.

Another interesting result can be gathered from Table 6, which shows that 50 percent of winning bids had a volume below CHF 75 million.

Table 7 provides summary statistics of successful participation. The left-hand side of the table provides aggregate information. We can infer from it that winning bids ranged between CHF 50,000 and CHF 500 million, with a median of CHF 10 million. The right-hand side shows the same information but broken down by auction day. The variation of minimum and maximum awards was much larger than in the aggregate, ranging from CHF 50,000 to CHF 1.561 billion, and the median volume was 15 times larger than in the aggregate.

The next set of results is summarised in Chart 9. It illustrates the evolution of winning bids over time for the four main bidding categories. The most visible change

was exhibited by the cantonal banks, whose awards declined from a peak at the beginning of the century of approximately one CHF 1 billion in an auction to zero in 2015. Only towards the end of the sample did their awards increase again beyond CHF 250 million. The tab seems to have been picked up mainly by the big banks, which, while exhibiting an inverted U-shaped curve, showed an overall stable market presence. A similar pattern can be observed for the other banks. Foreign banks' awards were more volatile. However, the strong pickup in their awards towards the end of the sample is akin to the observations for cantonal banks and especially other banks. One conclusion of this analysis is that successful investor base bidding in T-bill auctions is well diversified and overall stable despite the lack of a primary dealer system.

Finally, Chart 10 displays the distribution of awards. The upper histogram reports the sum of awards from CHF 0 to 100 million, and the lower histogram exhibits the sum of awards from CHF 100,000,001 and CHF 500 million. Awards were concentrated mainly in four volume sizes: 4,322 at CHF 0 to 1 million, 3,165 at CHF 9,001,001 to 10 million, 2,597 at CHF 49,001,001 to 50 million, and 2,451 at CHF 99,001,001 to 100 million. Awards at CHF 2, 3 and 4 million were also frequent. In contrast, awards beyond CHF 50 million to CHF 99 million were rare. In the lower histogram, three award concentrations can be identified: 102 at CHF 150 million, 54 at CHF 200 million, and 17 at CHF 250 million.

7.8 How well did investors fare with T-bills?

Investors examine several key factors before purchasing treasury securities. As with all types of investments, price, expected return, and risk play a role. Treasury securities provide a known stream of income and offer greater liquidity than other types of fixed-income securities. Their prices reflect these characteristics. Because the securities issued by the treasury are backed by the full faith and credit of the Confederation, they are often seen as one of the safest investments available (cf. section 4.2), although investors are not totally immune to losses. The behaviour of the market can lead to price changes that create some investment risk. For long maturity (nominal) bonds, unexpected inflation represents a major risk to investors. However, while this is of less concern for investors in T-bills, inflation can exceed the investment return and eat into the principal's value.

To obtain a perspective on whether it paid for investors to purchase T-bills, it is useful to look at Chart 11, which displays nominal yields together with consumer-price inflation. Except for a short spell between March 1982 and June 1983, nominal yields lay above inflation until the autumn of 2002. After that, except from August 2006 to December 2007, they were often below inflation, particularly after February 2016. The chart also shows that before 2009, the two curves moved in tandem. After that, some decoupling is noticeable.

Chart 12, which plots the real yield calculated as the difference between the nominal yield and the inflation rate, clarifies this point. Visual inspection reveals that overall, real yields have been above zero percent. This means that investors cashed in real income from T-bills. However, the dispersion was wide, especially at the beginning of

Chart 11: NOMINAL YIELDS AND INFLATION

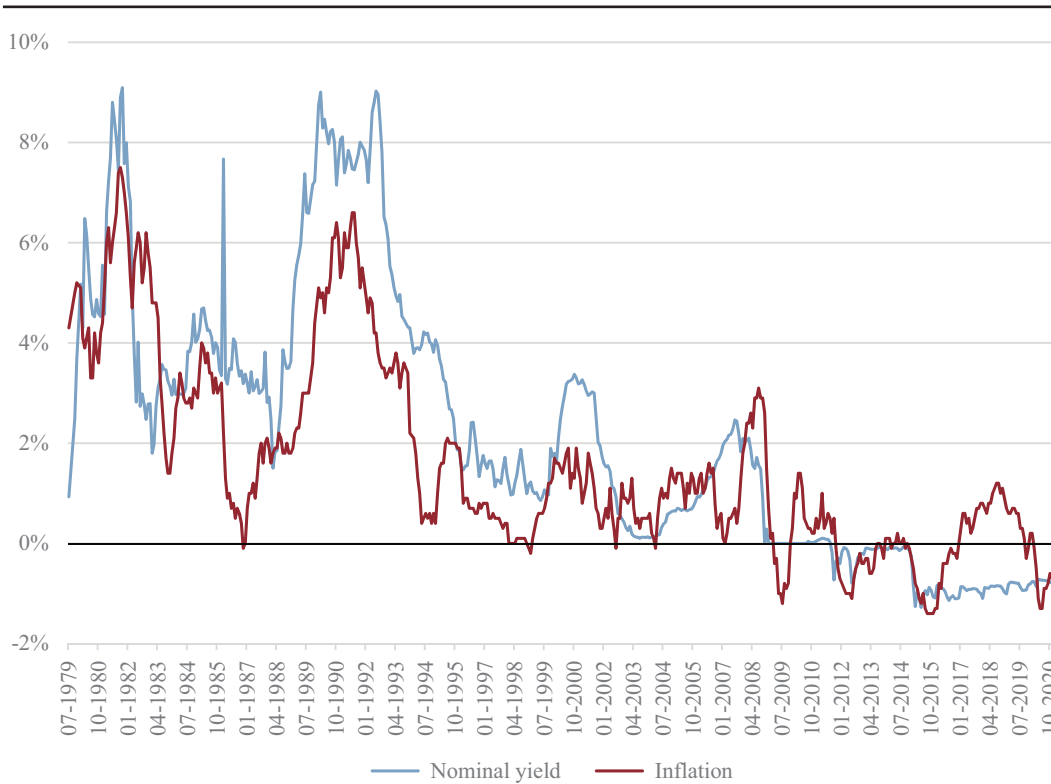


Chart 11: Nominal yields (in blue) and the inflation rate measured as monthly changes in the CPI relative to the corresponding month of the preceding year (in red).

Chart 12: REAL T-BILL YIELDS

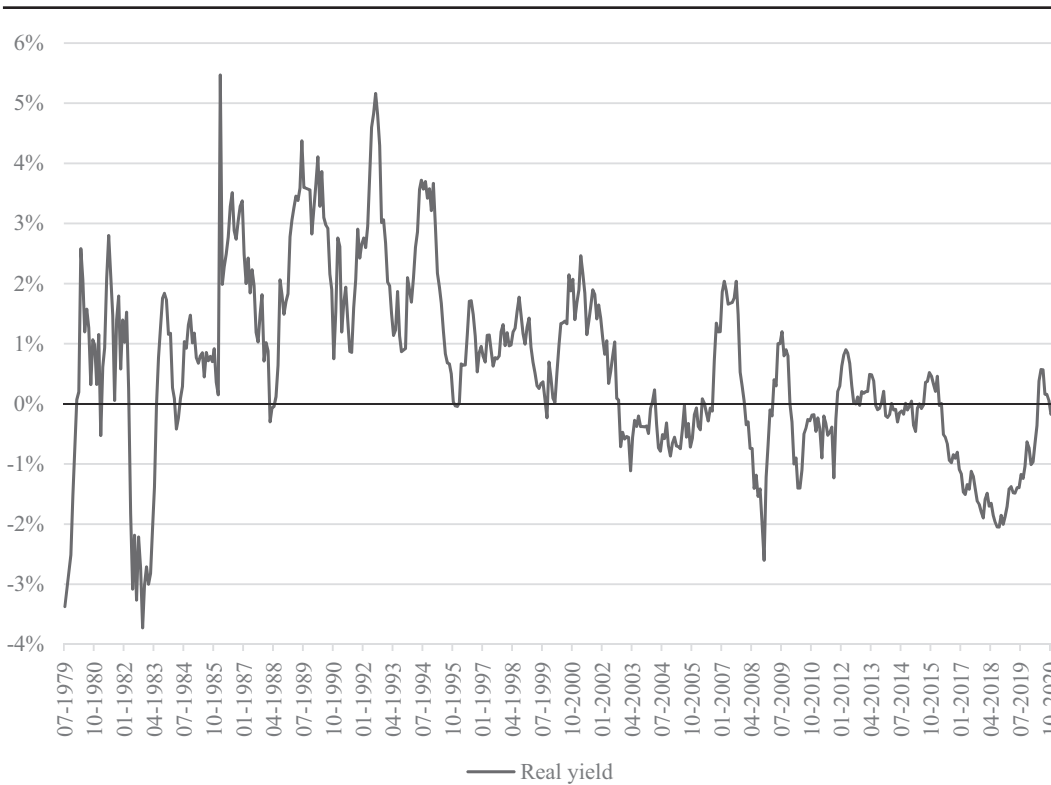


Chart 12: Real yields are calculated as the average nominal yield in a month minus the inflation rate of the same month calculated as the monthly change in the CPI over the previous year.

the sample period. The lowest real yield amounted to -3.72 percent and came about in October 1982. The highest real yield reached 5.47 percent and was realised in January 1986.

Echoing the evolution of nominal yields, real yields exhibit a falling trend since July 1992, hovering around or below zero since September 2002, which implies losses in real terms. Beginning in February 2016, real yields grew continuously negative and reached their nadir in June 2018 with -1.96 percent before turning into positive territory only in spring 2020. Negative real yields notwithstanding, demand for T-bills has been fairly steady. This is another reflection of the specialness of short-term Swiss government debt securities.

7.9 Revenue from negative yields

Since August 2011, nominal yields have been negative. This means that the Confederation has obtained money by incurring debt. This revenue totals CHF 502 million. The treasury could have arguably earned more by exploiting the full potential offered by the negative yield environment. Since August 2011, CHF 276 billion T-bills have been issued against a total demand of CHF 1,380 billion, tantamount to a cover ratio of 5. An increase in allotted volumes would have arguably generated more revenue.

Should the treasury put more emphasis on revenue in its operations in the future? Doubts are warranted. First, such an extension of the treasury's objective would violate the principle that in ensuring that the Confederation fulfils its payment obligations, the treasury's liquidity position is to be limited to that required as security for events that are unexpected or cannot be planned for (Swiss Federal Finance Administration FFA, 2014c). Moreover, art. 62 para. 1 of the Financial Budget Act states that the FFA invests the funds that are surplus to payment needs in such a way that ensures their security and a market-rate of return. A further constraint is posed by the debt break enshrined in the country's constitution. In 2012, then-head of the treasury Urs. Eggenberger commented on this issue: "Only to go into debt in order to get income cannot and must not be the task of the public sector. Therefore, we focus strictly on the funding needs." He recalled the debt limit and the fact that additional investments in roads or schools would entail consequential costs. He went on: "The state should not play with its creditworthiness[...]" and it "[...] is relevant to consider the long-term borrowing requirements to cover at minimal cost."⁶⁴ Another critical aspect relates to risk when the revenue from negative yielding liabilities would be invested in risky assets to raise their return.⁶⁵ Other effects are likely. For example, exploiting available demand until the point where yields reached the zero level would have impacted interest rates, counteracting the SNB's efforts to prevent short-term interest rates from increasing or forcing the SNB to take countermeasures.

64 Own translation from a German article in the newspaper *Der Bund* (2012).

65 Campbell and Shiller (1997), discussing the inappropriateness of a single-minded cost minimisation approach to public debt management, argued that a treasury could borrow at the T-bill rate and invest the proceeds in the stock market. Such a financing strategy would earn the government the equity premium, but the risk would be unacceptably high.

8. Conclusions

This study has analysed Swiss treasury uniform-price auctions of money market debt register claims in short T-bills conducted by the SNB on behalf of the treasury. Due to their short maturities and high issuance frequency, T-bills have been an important and reliable source to meet the Confederation's short-term financial needs and manage the treasury's short-term liquidity as well as the first choice for responding to rapidly changing funding needs. The lack of a formal primary dealer system has never given rise to a demand shortfall. All auctions were well covered. There was no need to change the treasury's straightforward and predictable funding strategy with its focus on auctions.

The first T-bill auction was held on 19 July 1979, in which an amount of CHF 211.00 million was borrowed. Since then, T-bills have been issued with great regularity, starting monthly and gradually increasing in frequency to weekly issues. Three maturity lines have been used: primarily three but also six and twelve months. From 19 July 1979 to 29 December 2020, the SNB ran 1,634 auctions, collecting bids from a great variety of institutional and private investors. Total borrowing amounted to CHF 1.121 trillion. The average nominal yield was 1.38 percent but exhibited great volatility.

The auction setup, borrowed sums, and frequency with which the SNB tapped the money market have evolved over time. Several amendments to auction rules were implemented in the 1980s and early 1990s. As a general trend, the entry barrier for private investors was lowered. One innovation in this context was the introduction of noncompetitive bids. Another important procedural change involved the discontinuation of announcements of targeted funding volume. The most relevant technical change was the switch from phone bidding to an electronic platform in February 2001.

The global financial and European sovereign debt crises necessitated reactions by the SNB with dramatic and lasting effects on the T-bill market. A downward yield trend set in motion in the early 1990s intensified and reached the zero bound in October 2008. In August 2011, the price cap of 100 was no longer market-conform because market rates had already been in negative territory for quite some time. A record-high volume of noncompetitive bids led to the removal of the price ceiling of 100 percent. Since then, T-bill auctions have cleared above par, implying a negative nominal and partly also negative real interest rate to investors. A nontrivial share of 29.8 percent of T-bill auctions were issued at negative yields until the end of December 2020. The revenue from negative nominal yields arising to the treasury amounts to CHF 502 million. However, negative yields have not left the market entirely unscathed. While demand has held up well, the numbers of bidders and bids have declined.

The datasets compiled and processed for this study provide a solid basis for in-depth empirical analyses of bidding behaviour and tests of theoretical predictions in future research. The values contained in dataset 1, which covers the whole time span from July 1979 until December 2020, could be compared to macroeconomic, financial and political variables to gain insight into the driving forces of the demand for T-bills at an aggregate level. Dataset 2 allows for a thorough investigation of bidding patterns at the individual direct bidder's level and lends itself to detailed tests

of theoretical predictions. This constitutes an important contribution to the existing literature on T-bill auctions for two reasons. First, two decades of granular data broken down to bidders' levels opens new perspectives in empirical research, which is often restricted to shorter time periods and aggregate bid data. Second, the examination of bidding behaviour in an environment of negative yields is a new field of research that offers a more precise understanding of the mechanisms at work and contributes to understanding the challenges in times of massive increases in public deficits and debts.

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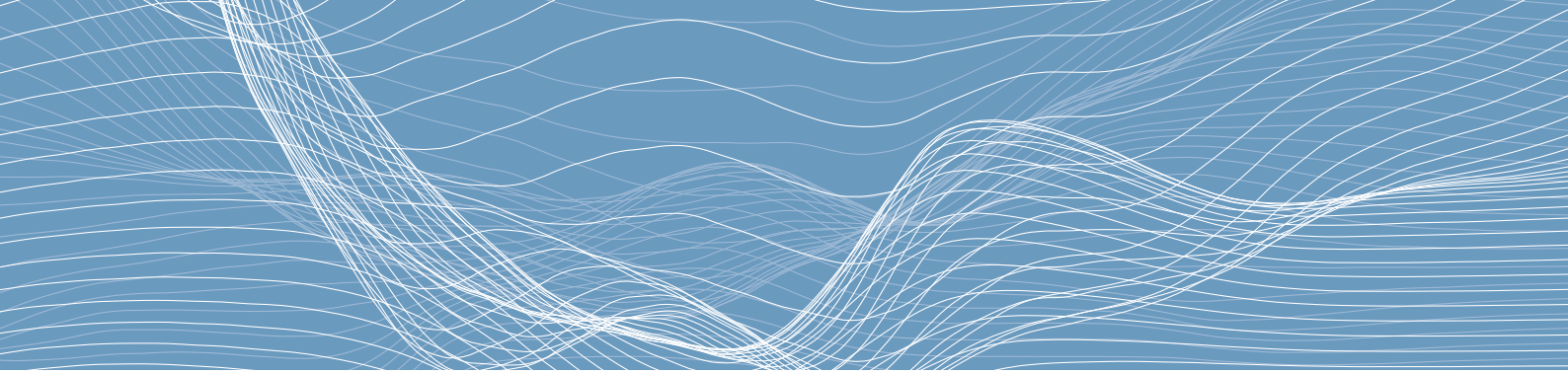
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