

Staff memo  
Central bank bond  
purchases and  
premiums—the Swedish  
experience

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# Summary<sup>1</sup>

I study the effect on short-term holding period interest rates from the government bond purchases conducted by the Riksbank in 2015-2017, a period when the Riksbank acquired 44 percent of the outstanding stock of nominal government bonds. I find that interest rates in the government bond market fell relative the policy rate, even for short holding periods, e.g. for one-day holding periods. More specifically, in the second half of 2017, investors invested in government bonds at short-term interest rates amounting to almost -0.90 percent even though the policy rate was set at -0.50 percent. Non-bank investors without access to central bank reserves thus faced interest rates clearly lower than the policy rate. One explanation why interest rates were lower for one-day investments in government bonds than in central bank reserves, could be that banks have use for government bonds in their banking operations, i.e. bonds enter bank's production functions and thus, falling interest rates in the wake of bond purchases simply reflect a higher marginal revenue product of additional government bonds.

Bond purchases are commonly believed to transmit also via a duration risk channel, causing interest rates on longer-dated assets to fall relative shorter-dated. However, the impact of government bond purchases on estimated term premiums, i.e. the expected return on government bonds relative central bank reserves, seems to be of the same order of magnitude as one would expect to see if bond purchases only transmitted via a channel going through banks higher marginal revenue product of government bonds. One explanation could be that any additional duration risk channel is of less significance.

Finally, I will show that the Swedish National Debt Office, the SNDO, endogenously responded to Riksbank purchases by providing more bonds to the market preventing short-term return to holding government bonds from falling below the Riksbank policy rate minus 0.40 per cent.

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<sup>1</sup> The author would like to thank Martin Flodén, David Vestin, Jens Iversen, Xin Zhang, Stefan Laséen, Jesper Hansson, Björn Lagerwall, Mikael Apel and Tommy von Brömsen for their valuable comments. All remaining errors are, of course, my own. The views expressed here are those of the author, and are not necessarily those of the Riksbank or its Executive Board.

# Introduction

Since the financial crisis of 2008/2009, several central banks have resorted to purchases of government bonds to make monetary policy more expansionary in order to support economic and inflation developments. The stated aim of these purchase programmes has been to lower *long-term* interest rates either by lowering the path of expected short policy rates, or by reducing the term premium of long-term bonds.<sup>2</sup> Comparably less attention has been paid to how purchases affect the *short-term* return that banks offer investors for holding government bonds relative to the interest rate on central bank reserves.<sup>3</sup> This paper aims to fill this gap in the literature.

I will show that banks often offer investors government bonds for short holding periods, at interest rates below the policy rate. One explanation could be that a bank operation requires bonds, e.g. for use as collateral or in liquidity coverage buffers and thus, bonds provide a service above the pecuniary remuneration paid by the issuer. We could thus think of bonds entering banks' production functions and the more bonds a bank holds at time  $s$ , the more business the bank can undertake that day.

This article investigates how this wedge between short-term interest rates for government bonds and central bank reserves developed in the period 2015-2017, when the Riksbank (the central bank of Sweden) acquired 44 percent of the outstanding stock of nominal government bonds. I make three main points.

First, on an aggregate level, the short-term return to holding government bonds, offered to investors, clearly fell relative the policy rate in 2015-2017 the larger the share of Swedish government bonds withheld by the Riksbank, indicating higher marginal revenue product of a bond to a bank. Indeed, by the end of 2017, banks offered investors interest rates almost 40 basis points below the policy rate, even for short holding periods, e.g. for one-day holding periods.

Second, the impact of government bond purchases on estimated term premiums seems to be of the same order of magnitude as one would expect if bond purchases only transmit by raising banks marginal revenue product of a bond, casting some doubt of the significance of an additional duration risk channel.

Third, I argue that there is a clear non-linearity in the relationship between the Riksbank's holdings of individual government bonds, and the spread between the offered short-term holding period return of that bond and the policy rate. This non-linearity is a consequence of how the Swedish National Debt Office, SNDO, endogenously responds to Riksbank purchases by supplying more bonds to the market. Via the so-called repo facility, SNDO provides an unlimited amount of any government bond at a daily holding period return corresponding to the Riksbank policy rate minus 40 basis points. Consequently, it is reasonable to expect that the supply of government bonds becomes perfectly elastic when market interest rates are close to the Riksbank's policy rate minus 40 basis points. Indeed, I will show that SNDO increased the supply of government bonds preventing short-term returns to holding any government bond from falling below the Riksbank policy rate minus 40 basis points. SNDO then invested the funds received in central bank reserves.

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<sup>2</sup> According to Bailey (2020), QE is defined as asset purchases that aims to lower long-term interest rates. Others see the reduction of long-term interest rates as a main, or the main channel of bond purchases. See e.g. Alsterlind et al (2015), Dudley (2010) and Yellen (2011).

<sup>3</sup> Flodén (2018) though concludes that asset purchases do affect interest rates on short holding periods.

I have organized this article as follows. First, I will briefly describe the data set used in this article and related literature. I will then introduce Swedish central bank reserves and the special feature that they are, at least in theory, transferable to non-monetary policy counterparties. We will see, though, that non-bank investors seem to have had limited access to central bank reserves, perhaps because of high entrance costs to this market. Thus, I argue that the Swedish operational framework worked in approximately the same way as traditional operational frameworks in which only monetary policy counterparties, or “banks”, have access to central bank reserves. Importantly though, in 2015-2017, SNDO had access to central bank reserves.

I will then devote a section to the introduction of the Swedish government bond market, with its characteristics of few bonds and a large share of repo transactions followed by a brief description of the Riksbank’s purchase programme in 2015-2017.

After that, I will turn to the more empirical parts. In the section “How short-term return to holding government bonds varied with Riksbank holdings”, I will show that the short-term returns investors meet fell in 2015-2017 amid large Riksbank purchases. I will then investigate whether bond purchases also transmit via a duration risk channel and finally, I will show how SNDO endogenously responded to Riksbank purchases via the repo facility.

First though a word on notation. Apart from the Riksbank and SNDO, I will describe the institutional framework governing two other agent types, banks and investors. I assume banks coincides with the subset of all agents that are monetary policy counterparties to the Riksbank, and thus have access to central bank reserves. I will denote the remaining agents, *investors*. I will thus use the term *investors* synonymous to those agents that cannot access central bank reserves.

## Data

I will use two data sets. One, supplied by SNDO, consists of ISIN level data on volumes supplied via the repo facility. The other, an ISIN level data set on interest rates on sell/buy-backs, was supplied by Nordea Markets<sup>4</sup>.

## Related literature

There is abundant empirical literature on the effects of asset purchases on interest rates and premiums, especially for the major central banks, e.g. Federal Reserve and Bank of England.<sup>5</sup> Premiums can though arise via different mechanisms. In the well-known model of Vayanos & Vila (2009), based on the preferred habitat theory attributed to Modigliani & Sutch (1966), two assets can differ in expected return if they belong to different maturity buckets. However, all ex ante determined

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<sup>4</sup> In this article, we will follow how these interest rates, expressed as spreads relative the policy rate, develop. However, in the raw data, these interest rates, in general, shift before a new policy rate is effective. Hence, from these interest rates, I have therefore deducted the policy rate effective in two business days. Still, there are a few observations, often in conjunction with policy rate shifts, where the spread relative the policy rate can be regarded as an outlier. I have defined an outlier as an observation where the spread is more than 10 basis points from the previous observation and where the spread in any of the two following observations is within 5 basis points from this same previous value. These few outliers were subsequently removed. Finally, the data set had some missing values. I have filled these dates with values deducted from a simple linear interpolation between the previous and subsequent observation.

<sup>5</sup> Noteworthy meta-studies are Williams (2014), Joyce et al. (2012) and Gagnon (2016). More recently, BIS (2019) and Bailey et al (2021) summarize central banks experience of asset purchases. There are few studies on the Swedish purchase programme and its effect on premiums. Some are though De Rezende (2017) and Diez de los Rios and Shamloo (2017).

interest rates converge to the same short rate when the investment horizon goes to zero. However, this model alone cannot explain Swedish data with, as we will see, multiple short rates.

Another set of models assumes that bonds traded in the market, to some agents, are associated with limited liquidity or transaction costs. In this category, we find Andrés et al (2004), Chen et al (2012), Harrison (2012) and De Graeve & Iversen (2015). We will though see that banks offer short-term investments in government bonds at interest rates below the policy rate. If government bonds would be associated with transaction costs, transaction costs would have to be negative, perhaps a non-intuitive friction. In this article, I will instead simply suggest that bank operations may require holding government bonds (e.g. bonds enter bank's production functions) and thus, banks associate a bond with a *value* above the pecuniary remuneration paid by the issuer. Since banks are monetary policy counterparts and thus set the relative price between government bonds and central bank reserves, this will induce a wedge between these two asset classes. This is analogous to Krishnamurthy & Vissing-Jorgensen (2012) where government bonds are included in the utility function of investors that set the relative price between government bonds and risky assets, e.g. private bonds. Thus, there are ways to introduce wedges or premiums not related to the duration of the asset. Which channels we should introduce in order to explain real world data, is of course largely an empirical issue.<sup>6</sup>

Several studies have investigated the effect of purchases on interest rates on repo transactions and potential spillover effects on bond prices.<sup>7</sup> Presumably, studies often analyse a sort of repo transactions called classical repurchase agreement. In this article, I will also investigate the effect of bond purchases on interest rates on a certain class of repo transactions, namely sell/buy back transactions, where an agent simultaneously purchase a bond spot and sell a bond with the same ISIN forward. We will see that, in Sweden, this is the most common way to transact a government bond and thus, one can argue, the interest rates on these transactions are the interest rates investors meet. Thus, these interest rates are also interesting in themselves.

## Swedish central bank reserves

Like in most other countries, Swedish agents can have a claim on two bodies belonging to the consolidated government; on the central bank, i.e. the Riksbank, or on the national debt office, i.e. the Swedish National Debt Office (SNDO). In this article, I will describe two such assets, central bank reserves that are claims on the central bank and government bonds that are claims on the SNDO. I will now describe these in turn, starting with central bank reserves.

Conventionally, only the subset of all agents fulfilling certain criteria can be monetary policy counterparties, implying they can hold central bank reserves, access standing facilities and participate in open market operations.<sup>8</sup> This is also the case in Sweden and I will simply refer to this group of agents as *banks*.<sup>9</sup> However, the Swedish operational framework entails a special feature implying that banks, at least in theory, can transfer central bank reserves to any other agent. More specifically, in 2015-2017, banks could allocate their central bank reserve holdings either to an account at the

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<sup>6</sup> Different studies stress different transmission channels of asset purchases. Altavilla et al (2015), for example, conclude that ECB purchases affected Euro denominated bonds via a duration risk channel, e.g. implying a more pronounced effect if the assets are long-dated. In contrast, Krishnamurthy & Vissing-Jorgensen (2011), find no evidence that bond purchases conducted by Federal Reserve transmitted via a duration risk channel.

<sup>7</sup> Example of studies are D'Amico, Fan, Kitsul (2018), Arrata, Nguyen, Rahmouni-Rousseau, Vari (2018) and Ferrari, Guagliano, Mazzacurati (2017). All these papers investigate, and find a statistically significant relationship between central bank bond purchases and interest rates in the repo market. Some studies, e.g. Jordan and Jordan (1997) and D'Amico, Fan, Kitsul (2018), also explore empirically how interest rates in the repo market affect prices and interest rates in the bond market.

<sup>8</sup> Bindseil (2016) includes a discussion of the costs and benefits of expanding the list of counterparties from the existing subset of agents.

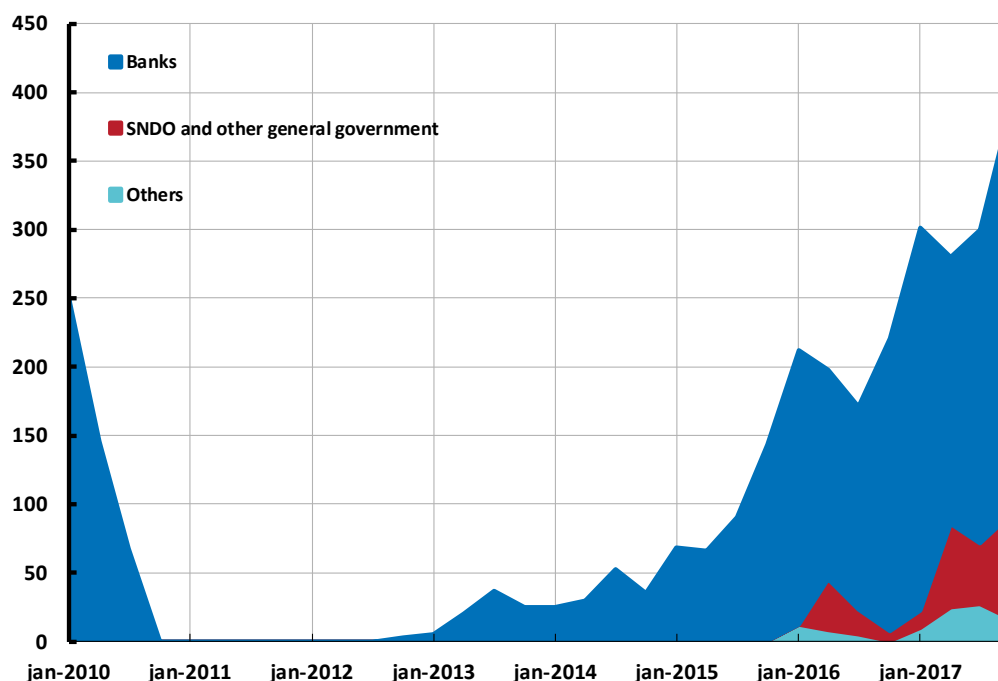
<sup>9</sup> All major Swedish banks are monetary policy counterparties to the Riksbank and, as we will see, primary dealers with SNDO.



Riksbank or to securities issued by the Riksbank, Riksbank certificates. Banks then had the possibility to, at their own discretion, sell these certificates to any other agent.

A natural question is whether this peculiarity of the Swedish operating framework implied that also any other agent had full access to central bank reserves and thus could act as arbitrageurs between central bank reserves and government bonds? I will soon show that, in 2015-2017, non-bank investors faced short-term interest rates in the government bond market far below the policy rate. Despite this, few investors purchased Riksbank certificates from intermediating banks, perhaps indicating high entrance costs into this market (See Figure 1). However, there was one non-bank agent purchasing large quantities Riksbank certificates, SNDO. To keep the exposition tractable, I will henceforth describe the Swedish framework as if only banks and SNDO had full access to Swedish central bank reserves.

Figure 1. Holdings of Riksbank certificates, SEK bn



Source: Statistics Sweden.

## The Swedish Government Bond Market

Swedish government bonds are issued by the Swedish National Debt Office, SNDO. In general, the number of Swedish government bonds has been few, e.g. by the end of 2017 there were nine different bonds, also called *loans*. Every loan is assigned a unique ISIN code, but is normally referred to by a serial number corresponding to the order in which the bond was first launched, e.g. 1058, 1059, 1060 etc. The Swedish National Debt Office, SNDO, borrows money by tapping any of the outstanding loans.

**Table 1. All SEK denominated outstanding government bonds in December 31, 2017**

Loan	Maturity	Outstanding volume, SEK bn
1052	2019-03-12	98.55
1047	2020-12-01	96.05
1054	2022-06-01	103.63
1057	2023-11-13	84.48
1058	2025-05-12	59.38
1059	2026-11-12	61.89
1060	2028-05-12	45.86
1056	2032-06-01	16.50
1053	2039-03-30	45.25

Source: SNDO

SNDO has contracted the major banks as primary dealers.<sup>10</sup> Henceforth, I will simply refer to this group of primary dealers as *banks*.<sup>11</sup> According to the contract with SNDO, banks undertake to inform investors about SNDO's borrowing, maintain a secondary market, contribute to secondary market liquidity and price transparency and, on request, provide firm bid and ask quotes to investors.<sup>12</sup> Simply put, the primary dealer agreements give investors full disclosure and access to the government bond market. In return, SNDO pays the participating banks a fee.

An investor can buy Swedish government bonds in three different ways; spot, forward or as part of a repo transaction. Let us number the outstanding government bonds  $\{1, 2, 3, \dots, n\}$ . Then, a spot transaction implies that the investor, at time  $t$ , agrees to purchase a bond, say bond  $j$ , at time  $t$  to a price  $P_t^j$ .<sup>13</sup> A forward transaction implies that the investor, at time  $t$ , agrees to buy the bond at a future date  $s$  to a predetermined price,  $P_{s|t}^j$ , set at time  $t$ .

However, a feature of the Swedish bond market is the extensive use of repo transactions, which in Sweden conventionally has been in the form of *sell/buy-backs*.<sup>14</sup> One can think of these transactions as two separate transactions, one spot and one forward, agreed upon at the same point in time. More specifically, at time  $t$ , an investor buys (sells) a bond  $j$  from a bank spot and simultaneously agrees to sell (buy) a bond of the same ISIN back to the bank forward, e.g. at time  $s$ . Banks quote the ratio between the current and future bond price as an interest rate, reflecting the holding period return of the bond.<sup>15</sup> Thus, these sell/buy-backs offer the opportunity to invest in bonds, e.g. 10-year bonds, for a pre-specified holding period, say one week, at an ex ante determined holding period return. Often, these transactions have a relatively short tenor, sometimes only one day long.<sup>16</sup>

<sup>10</sup> The Swedish term is "Återförsäljare".

<sup>11</sup> The largest monetary policy counterparties to the Riksbank are also primary dealers with SNDO. Thus, banks have complete access to central bank reserves and government bonds.

<sup>12</sup> The primary dealer contracts are available on the SNDO website.

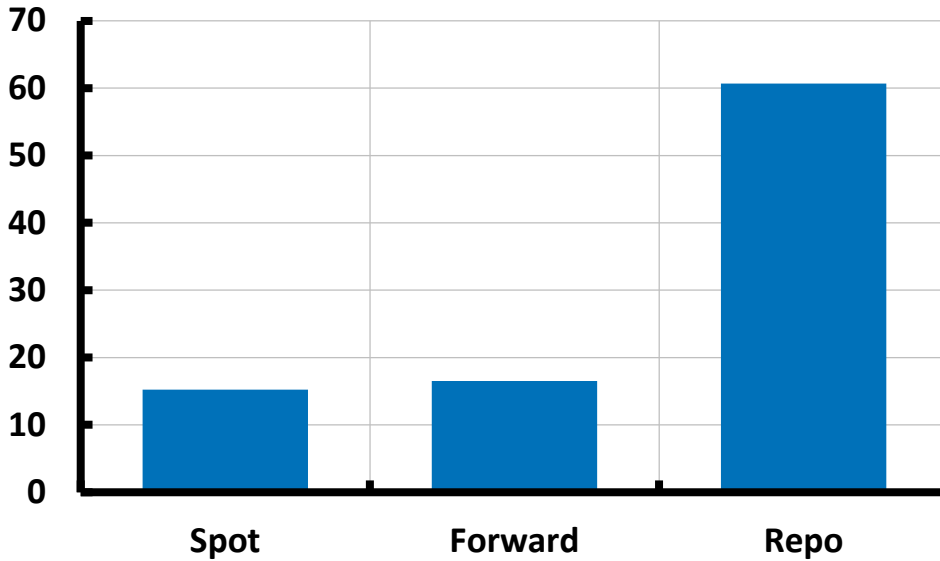
<sup>13</sup> In reality, a spot transaction normally implies that bonds are sold in two business days, a convention called T+2.

<sup>14</sup> A "repo" is a generic name for a collection of transactions that are divided into two subgroups, A) classical repos or repurchase agreements and B) sell/buy-backs. The conventional form of repo in Sweden has been sell/buy-backs. We can regard the interest rate on a sell/buy-back for a particular bond as a market quote of the forward rate of the bond and for one-day tenors, the interest rate is thus a market quote of the instantaneous forward rate. World Bank (2010) contains an overview of the difference between the two forms of repos.

<sup>15</sup> For simplicity, I describe sell/buy-back transactions assuming there are no coupon payments between the spot and forward settlement days. If there are coupon payments between the spot and forward settlement days, the interest rate on the transaction will reflect the holding period return including coupon payments.

<sup>16</sup> According to International Capital Market Association, ICMA (2013), approximately 51 per cent of all repos were shorter than one month. However, in 2009-2017, the average monthly turnover in the Swedish spot market for government bonds, excluding repos, amounted to approximately half the outstanding bond stock. Thus, the median holding period for government bonds is relatively short, whether or not purchases are part of a repo transaction.

Figure 2. Average daily turnover in Swedish government bonds, 2009-2017, SEK bn.



Source: The Riksbank

Agents sometimes express the interest rate on short tenor sell/buy-back repo transactions as a spread relative the policy rate. In this spirit, let us define  $\omega_t^j$  as

$$r_t^j = i_t - \omega_t^j, \quad j = 1, 2, \dots, n \quad (1)$$

,where  $r_t^j$  and  $i_t$  denote the interest rate on a one-day term sell/buy-back and the policy rate respectively.

Interestingly, as we will soon see, banks frequently quote one-day holding period interest rates on government bonds below the policy rate, i.e.  $\omega_t^j$  is often strictly positive. One explanation could be that a bank operation requires bonds, e.g. for use as collateral or in liquidity coverage buffers and thus, bonds provide a service above the pecuniary remuneration paid by the issuer. We could thus think of bonds entering banks' production functions and the larger the portfolio of bonds a bank holds at time  $s$ , the more business the bank can undertake that day.<sup>17</sup> In this case, it is reasonable to expect the marginal revenue product of bonds to be at elevated levels at time  $s$  (i.e.  $\omega_t^j$  to rise for  $t=s$ ) in the wake of an exogenous shock that reduces the amount of available bonds in  $s$  to  $s+1$ .<sup>18</sup> We will also soon see that one-day holding period interest rates may differ between bonds indicating they are not perfect substitutes.<sup>19</sup>

The reason why *investors* buy government bonds at one-day holding period returns below the policy rate is more obvious. As explained above, apart from SNDO, I assume that non-bank agents, in general, do not have access to central bank reserves and thus, the policy rate is not an opportunity cost to these agents.

<sup>17</sup> In this article, I will only describe two asset classes, central bank reserves and government bonds and since banks are monetary policy counterparties, they set the relative price between these two asset classes. Although investors cannot hold central bank reserves, in reality, they also hold assets other than government bonds, e.g. more risky bonds or physical capital. Safe asset literature such as Krishnamurthy & Vissing-Jorgensen (2012) and Brunnermeier et al. (2020) explore how investors set the relative price between government bonds and these more risky assets and argue that government bonds are associated with a *convenience yield* stemming from their ability to preserve value and liquidity even in stressed states of the economy. In Krishnamurthy & Vissing-Jorgensen (2012), government bonds explicitly enter investor's utility functions analogous to how I assume they enter bank's production functions.

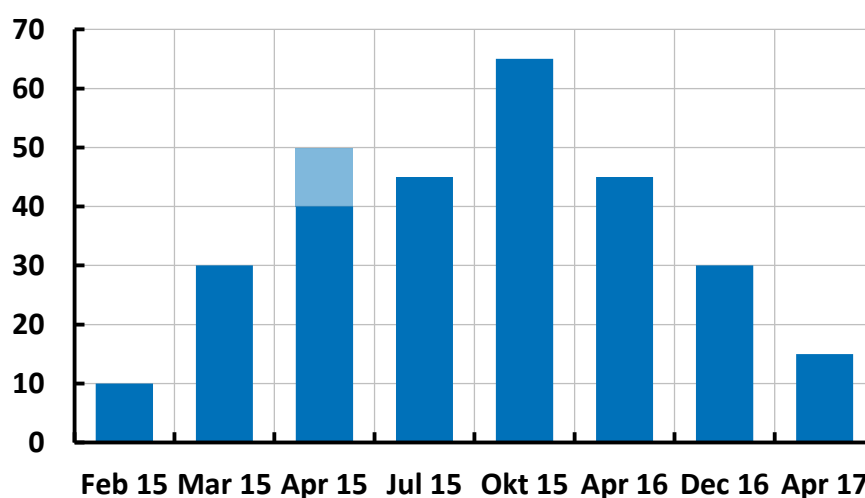
<sup>18</sup> If the stock of bonds, available to banks, slumps, banks will only execute the most profitable bank operations.

<sup>19</sup> Thus, banks will hold a diversified portfolio of bonds for use in the production of financial services.

## The Riksbank purchase programme of 2015-2017

In February 2015, the Riksbank announced it would commence monetary policy motivated government bond purchases.<sup>20</sup> According to this announcement, the Riksbank would execute a round of purchases amounting to SEK 10 billion. However, the Riksbank increased the envelope of the programme in several steps. Initially, the Riksbank only purchased nominal government bonds but in 2016, it also added index-linked government bonds to the list of eligible instruments.

**Figure 3. Announced purchase volumes by announcement day. Nominal volume, SEK bn**



Source: Riksbanken

Note. In March 2015, the Riksbank decided to increase the envelope of the bond purchase programme. The additional volume that was going to be purchased was stated as an interval, SEK 40-50 bn.

By the end of 2017, the Riksbank owned SEK 305 bn government bonds. SEK 267 bn was nominal government bonds, corresponding to 44 percent of the nominal government bond stock. In December 2017, the Riksbank communicated that it would stop net purchases but reinvest coupon payments and payments of nominal values at redemption.<sup>21</sup> The nominal bonds that the Riksbank purchased in 2015-2017 are those displayed in Table 1 plus two bonds, 1050 and 1051, that matured during the programme, in July 2016 and August 2017 respectively. However, the 1050 bond was only purchased in a negligible quantity, SEK 1.5 bn.

<sup>20</sup> In 2012, the Riksbank also decided it would acquire a portfolio of SEK 10 bn bonds. The purpose of this portfolio was to increase preparedness if monetary policy motivated purchases were required.

<sup>21</sup> Formally, the Riksbank already took the reinvestment decision in February 2016.

## How short-term return to holding government bonds varied with Riksbank holdings

In the standard Euler equation, the ratio of the marginal utility of consumption between two adjacent periods is linked to the one-period holding return of an asset. To keep models tractable, it is often assumed that households only save in one-period bonds, in which case the one-period return corresponds to the, ex ante determined, interest rate on the bond.<sup>22</sup>

For the Swedish case, there are arguments for considering using quoted interest rates on one-period repos in investor's budget constraints and Euler equations.

- It allows us to use frameworks with one-period interest rates even in the absence of one-period bonds. This follows from the fact that repos in Sweden are conventionally of the form of sell/buy-backs where an investor purchases a bond spot and sells a bond with the same ISIN forward.
- Investors that lack access to central bank reserves are confined to the government bond market, where the most common way to transact a Swedish government bond is via repo transactions (see Figure 2).<sup>23</sup> If the most common way to invest in a bond is via these repo transactions, one can argue that the interest rates on these transactions are the interest rates investors meet.

Now, let us see how these interest rates developed in a period including the Riksbank purchase programme. The blue line in figure 4 shows the average, outstanding volume weighted, interest rate,  $\bar{r}_t$ , on sell/buy backs for one day tenors, minus the policy rate,  $i_t$ . The bars in the same figure show the outstanding volume of nominal government bonds where the red part of the bars represents the share owned by the Riksbank.

We see that interest rates were not at a constant level relative the policy rate before the Riksbank started to accumulate bonds. They showed some variation and were in general lower than the policy rate. Thus, other factors than Riksbank purchases affect these interest rates. However, these interest rates apparently fell relative the policy rate, the greater the share of the outstanding stock of government bonds withheld by the Riksbank.<sup>24</sup> More specifically, at the end of 2017, the spread between the one-day period interest rate and the policy rate was, on average, 24 basis points lower than the average level in 2014, the last year preceding the bond purchase programme and 29 basis points lower than the level prevailing at the turn of the year 2014/2015. Let us conclude that the short interest rates investors met seem to have fallen 24 to 29 basis points relative to the policy rate, in the period when the Riksbank purchased a large share of the outstanding stock of government bonds. One interpretation of the falling interest rates, as mentioned previously, is that banks may have decreasing marginal revenue product of holding bonds. Thus, when the available stock of bonds decreases, the marginal value of additional bonds increases and, consequently, banks quote a lower interest rate to be indifferent between government bonds and central bank reserves.

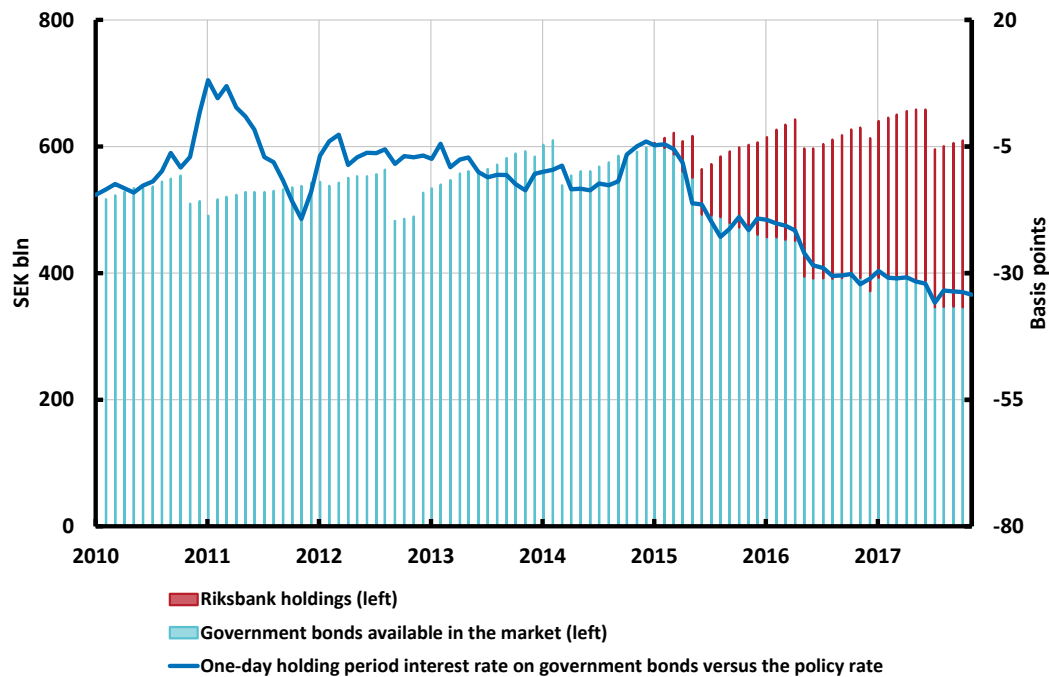
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<sup>22</sup> However, there are models allowing households to invest in long-term bonds. Examples are Chen (2012) and Harrison (2012) where households can save in perpetual bonds, to an expected (ex post determined) one-period return.

<sup>23</sup> Between 2009 and 2017, the average daily turnover for government bonds was SEK 15 bn in the spot market (i.e. excluding forwards and repos) and SEK 61 bn in the repo market, in Sweden predominantly consisting of sell/buy-backs.

<sup>24</sup> Apart from Riksbank purchases, other factors may affect the short-term holding period return investors meet. However, in the period 2015-2017 the Riksbank acquired 44 percent of the outstanding stock of nominal bonds and thus, it could be reasonable to expect most variation to stem from these purchases.

**Figure 4. Short-term returns on holding government bonds fell when the Riksbank accumulated bonds**



Source: The Riksbank, Nordea Markets

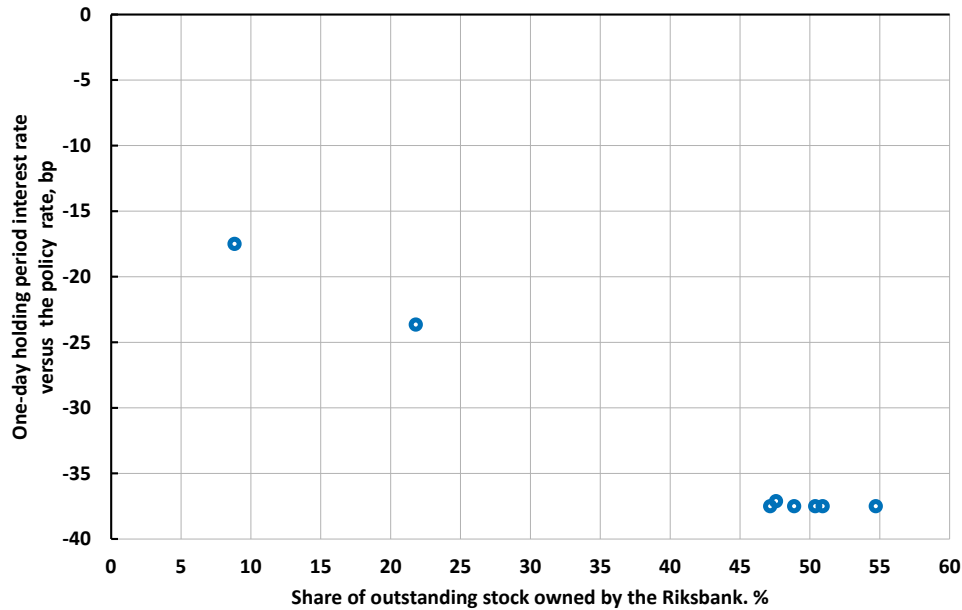
Note. The figure shows end-of-month values. For any given month, the blue line represents the average, outstanding volume weighted, one-day interest rate on a government bond repo transaction versus the policy rate, for all bonds where we had a notation.<sup>25</sup> In the figure, interest rates seem to be slightly above a level corresponding to the Riksbank policy rate minus 40 basis points, even by the end of December 2017. However, all interest rates in this article are mid prices, i.e. the average of the bid and ask rates. Agents wishing to invest money, i.e. buy first and sell later, will thus face a slightly lower interest rate, closer to 40 basis points below the policy rate.

Thus, on an aggregate level, larger Riksbank holdings, as a share of the total outstanding stock, seemed to be associated with one-day holding period interest rates being at a lower level relative the policy rate.

However, bonds were not affected equally by the purchase of an arbitrary government bond, implying bonds are not perfect substitutes. As an illustration, consider Figure 5, which shows the relationship between interest rates and Riksbank holdings on an ISIN-level, by the end of December 2017. The Riksbank owned a smaller share of bonds of two different ISINs and apparently, one-day holding period interest rates were higher for these bonds. Thus, investors were guaranteed a substantially higher interest rate if they invested one day in one of these two bonds than in bonds where the Riksbank had around half of the outstanding stock.

<sup>25</sup> There are a few months where we do not have interest rate notations for all bonds, e.g. the month a new bond is launched, there is not always market quotes on that particular bond.

Figure 5. Interest rates relative Riksbank holdings on an ISIN-level. End December 2017.<sup>26</sup>



Source: The Riksbank, Nordea Markets

I have now provided evidence on the first of the propositions in the introduction. Short-term return to holding government bonds fell relative the policy rate in 2015-2017 the larger the share of Swedish government bonds bought by the Riksbank, and were, on an aggregate level, almost 40 basis points below the policy rate by the end of 2017.

## Is there a duration risk channel?

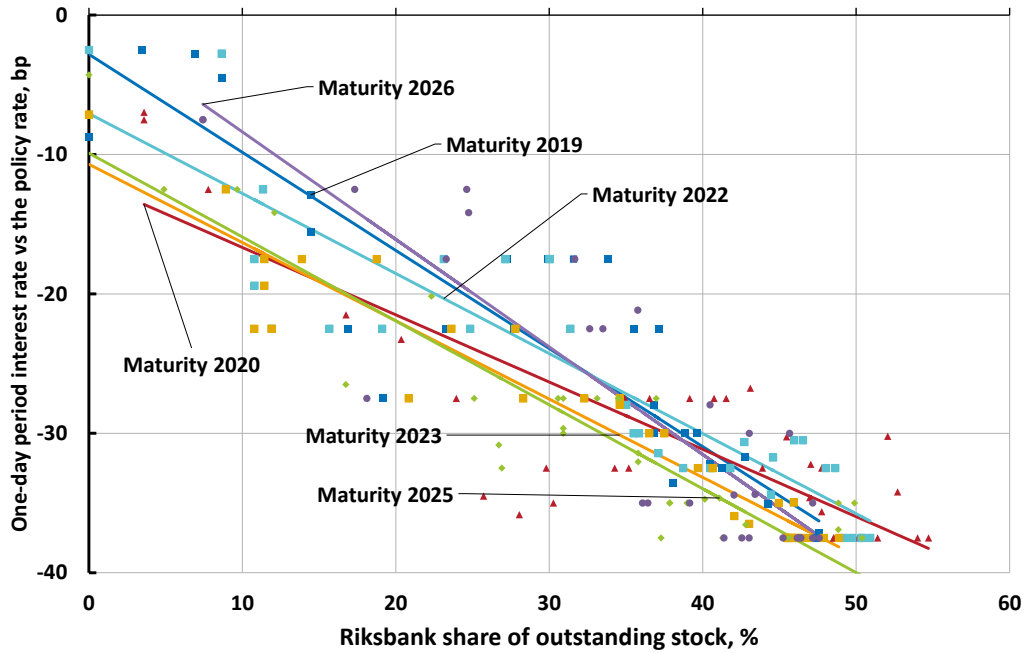
A common presumption is that central bank bond purchases affect interest rates via a duration risk channel, a channel incorporated in the well-known model of Vayanos and Vila (2009). The price of longer-dated bonds are more sensitive to movements in interest rates than shorter-bonds. Thus, the central bank can reduce duration risk in the market by purchasing long-dated assets compressing the interest rate on these relative shorter dated assets. One characteristic of the duration risk channel is, according to Krishnamurthy and Vissing-Jorgensen (2011), that the effects of bond purchases are larger for longer-duration assets. Let us see whether this was the case for Sweden.

As we saw in Figure 5, the short holding period interest rates were roughly 40 basis points below the policy rate for bonds of six different ISINs. Figure 6 plots the relationship, on an ISIN-level, between Riksbank holdings and the spread between one-day period government bond interest rates and the policy rate, for these bonds.<sup>27</sup>

<sup>26</sup> In the figure, interest rates seem to be slightly above a level corresponding to the Riksbank policy rate minus 40 basis points. However, interest rates are mid prices, i.e. the average of the bid and ask rates. Agents wishing to invest money, i.e. buy first and sell later, will thus face a slightly lower interest rate, closer to 40 basis points below the policy rate.

<sup>27</sup> In a formal analysis of how the Riksbank's holdings of a bond affect the interest rate on that particular bond, one may have to control for some variables, e.g. the volume of other assets held by the Riksbank or the state of the macro economy. By the end of 2017, the Riksbank held government bonds of 8 different ISIN codes. To some extent, however, they were purchased in two different periods. Large shares in 6 of these bonds were purchased predominantly in 2015-2016 (85 percent of the volume held at the end of 2017 in these six bonds were purchased during 2015-2016). Only a limited fraction of the other two bonds were purchased and these acquisitions occurred, predominantly, at a later stage in 2017 when the

Figure 6. Bond purchases have similar effects on short- and long-term bonds



Source: The Riksbank, Nordea Markets

Note. The figure contains dots with 6 different colours, one for each bond. For each bond, there are 35 dots, showing offered one-day holding period interest rates vs the policy rate and the Riksbank's share of the outstanding stock for this particular bond at the end of each month from February 2015 to December 2017. For every bond I have also fitted a line with ordinary least squares,  $\omega_t^j = \alpha^j + \beta^j \chi_t^j$ , where  $\omega_t^j$  is the offered daily interest rate vs the policy rate in basis points and  $\chi_t^j$  is the share of bond  $j$  withheld by the Riksbank.

Interestingly, the slope of the lines is of the same order of magnitude and not apparently related to the maturity of the bond. Hence, purchases seem indeed to have a similar effect on one-day holding period interest rates, regardless of the maturity of the bond.<sup>28</sup> Thus, based on the effects on short-term return on holding different government bonds, bond purchases seem to affect long-maturity bonds in a similar way to short-maturity bonds. However, international empirical studies of central bank purchases suggest bond purchases can affect the *term premium* of 10-year bonds. Does this imply that there is, after all, a channel related to the maturity of a bond?

The term premium,  $tp_t^j$ , of a bond  $j$ , that matures in  $T^j$ , is often defined as the residual when the average expected policy rate during the lifetime of the bond is deducted from the yield to maturity,  $y_t^j$ , i.e.<sup>29</sup>

$$y_t^j = \left\{ \frac{1}{(T^j - t)} \sum_{s=0}^{T^j - t - 1} i_{t+s|t} \right\} + tp_t^j \quad (2)$$

Riksbank already owned a large share of the total outstanding stock of government bonds. More than 85 per cent of the volume held at the end of 2017 in these two bonds were purchased in 2017. In Figure 6, I have not included the two bonds that, to a large extent, were acquired at a later stage.

<sup>28</sup> If we were to add the bonds maturing in 2028 and 2039 that were predominantly purchased at a later stage, the slope of these bonds would be slightly steeper. A possible explanation is that these two bonds were primarily acquired at a later stage when the Riksbank already withheld a large share of the outstanding stock of nominal bonds. Thus, there were less available substitute bonds when the Riksbank started buying these bonds and thus, the effect was slightly larger. An alternative explanation is that these two bonds are the bonds with the longest time to maturity. Figure 6 though indicates that there is no apparent relationship between the effect on one-day holding period interest rates and the maturity of the bond, for other maturities.

<sup>29</sup> See Alsterlind et al. (2015).



Assume banks quote the yield of a bond with  $n$  periods to maturity as the expected value of  $n$  consecutive one-period investments in the same government bond plus a premium,  $\Delta_t^j$ , related to the duration risk of the bond, i.e.<sup>30</sup>

$$y_t^j = \left\{ \frac{1}{(T^j-t)} \sum_{s=0}^{T^j-t-1} r_{t+s|t}^j \right\} + \Delta_t^j \quad (3)$$

Combining equations 1, 2 and 3, enables us to decompose the term premium into two parts. One part reflecting banks' marginal revenue product of holding a bond for one day, and one part related to the duration risk, i.e.

$$tp_t^j = \phi_t^j + \Delta_t^j \quad (4)$$

where<sup>31</sup>

$$\phi_t^j = - \left\{ \frac{1}{(T^j-t)} \sum_{s=0}^{T^j-t-1} \omega_{t+s|t}^j \right\} \quad (5)$$

In the section “*How short-term return to holding government bonds varied with Riksbank holdings*”, I concluded that short-term returns on holding government bonds hovered slightly below the policy rate and then shifted down 24 to 29 basis points in the wake of Riksbank purchases. When the Riksbank, in December 2017, announced a halt to new *net* bond purchases, it declared that redemptions and payments from coupons would still be reinvested until further notice to prevent Riksbank holdings from decreasing.<sup>32</sup> Let us assume agents consequently expected holdings to be persistent and thus sufficient to keep short-term returns at the new level, i.e. assume  $\phi_t^j$ , on average, shifted down 24 to 29 basis points. From equation 4, we can thus see that bond purchases shifted term premiums 24 to 29 basis points *plus* a term related to the duration risk.

To get a feel for the impact of the duration risk channel, let us take a brief look at the results of other studies. De Rezende (2017) estimated that term premiums in the 5-10 year segment shifted 18.2 to 19.6 basis points due to the first chunk of Riksbank purchases of nominal government bonds that amounted to SEK 200 bn.<sup>33</sup> If these estimates are linearly scaled to the SEK 267 bn the Riksbank owned by the end of 2017, we would get an estimate of the total shift in term premiums of 24 to 26 basis points.<sup>34</sup> However, if we believe  $\phi_t^j$  in equation 4 shifted down 24 to 29 basis points, we can only get an estimate of the total shift in term premiums of 24 to 26 basis points if the duration risk channel is negligible, i.e. bond purchases do not affect  $\Delta_t^j$  much.

<sup>30</sup> I denote the expected value at time  $s$  of a variable  $r_s$  conditioned on the information available at time  $t$ ,  $r_{s|t}$ , i.e.  $r_{s|t} = E_t[r_s]$ .

<sup>31</sup> If  $\omega_t^j$  depends on Riksbank holdings at time  $t$ , a part of the term premium would, according to equation 5, reflect the expected trajectory of Riksbank holdings during the lifetime of the bond. Thus, term premiums depend on the total amount of bonds agents expect the central bank to accumulate in an asset purchase programme, a point stressed by others, e.g. D'Amico & King (2013). As a corollary, there can be a term premium of bonds with both short as well as long time to maturity and depending on the expected trajectory of Riksbank holdings, either can have the highest absolute value. As an illustration that the absolute value of the term premium can be different from zero also for short-dated bonds, consider the second half of 2017, when the policy rate amounted to -0.50 percent. In this period, the median respondent's policy rate projection in the Prospera/Kantar Survey always amounted to at least -0.50 at all horizons. Despite this, the yield to maturity of the shortest bond maturing in March 2019 was, on average -0.75 percent, roughly 40 basis points below the rate implied from the RIBA contracts that is often used as a measure of the expected policy rate. In November 2017, the yield to maturity of the bond reached almost -0.90 percent.

<sup>32</sup> To reinvest coupon payments and redemptions from nominal government bonds was already decided in February 2016. Annex B to the February 2016 minutes stated that “if no reinvestments are made, both the Riksbank's holdings of nominal Swedish government bonds and the liquidity surplus will decrease”. In December 2017, the Riksbank halted new purchases and henceforth only intended to purchase bonds to reinvest coupon payments and redemptions in compliance with the February 2016 decision.

<sup>33</sup> See estimates in Table 7 in De Rezende (2017). Please note that the method used do not result in any shift in term premiums for shorter investment horizons, e.g. less than 5 basis points for segments below 2 years.

<sup>34</sup> The term premium is here defined as the yield to maturity of a bond minus the average expected one-month rate over the same period. Data on one-month rates are retrieved from yields on short treasury bills that have not been subject of purchases by the Riksbank and could thus be assumed to be a decent proxy for the policy rate. This is of course only an approximation. Treasury bills could, at least to some extent, be regarded as substitutes for government bonds. Thus, purchases of government bonds could potentially, to some extent, also affect treasury bill prices.

Diez de los Rios and Shamloo (2017) study the period until April 2016 when the Riksbank had announced purchases amounting to approximately 90% of the volume the purchase programme reached in December 2017. They define the term premium as the yield to maturity of a bond minus the average expected *one-year* rate over the same period. At the time, there were neither central bank reserves nor any treasury bills as long as one year in Sweden. Thus, we can presume the one-year yield is also an interest rate from government bonds affected by Riksbank purchases. With this definition, we would expect small shifts in term premiums, if there is no additional effect related to the duration of a bond. And indeed, Diez de los Rios and Shamloo (2017) find that the aggregated effect on 10-year bond term premiums due to Riksbank purchase announcements was an insignificant +4 basis points.

Concluding, it seems estimates of the impact on long-term bond term premiums from Riksbank purchases are of the same order of magnitude as one should expect if there was only a shift in the marginal value product of holding a bond for a day, without any additional effect emanating from a duration channel. Of course, one should be very cautious when comparing estimates deduced in different frameworks. However, I think it is fair to say that we do not yet have compelling evidence that bond purchases, to a significant extent, transmit via a duration risk channel. Thus, I have now provided information on proposition 2 in the introduction.

## The endogenous response from SNDO to Riksbank bond purchases

In the introduction, I stated three propositions that I intended to investigate in this staff memo. I will now turn to the last of these, namely the proposition that, for a given Riksbank policy rate, the SNDO repo facility induces a floor to short-term holding period interest rates on government bonds and hence, there is a non-linearity in the relationship between the Riksbank's holdings of individual government bonds, and these short-term interest rates.

The SNDO repo facility implies that banks, at any point in time, can buy an unlimited amount of any government bond and sell back the same volume bonds with the same ISIN to SNDO the day after.<sup>35</sup> SNDO's transactions are, of course, sell/buy-backs. The interest rate on these sell/buy-backs amounts to the Riksbank policy rate minus 0.40 percentage points.<sup>36</sup>

Please note that bonds are fungible and thus, there is no direct link between how banks sell government bonds and how they buy them. A bank can thus buy government bonds in sell/buy-back transactions from SNDO and sell these spot, e.g. to investors that have sold government bonds spot to the Riksbank.

In the section "*How short-term return to holding government bonds varied with Riksbank holdings*" above, I showed that Riksbank purchases tended to lower sell/buy-back interest rates on government bonds. However, when these rates are at a level corresponding to the Riksbank policy rate minus 40 basis points, further Riksbank purchases cannot affect these interest rates. To see why, consider a scenario where the Riksbank withholds an additional volume of every bond, say,  $\mathbf{v} = [v_1, v_2, \dots, v_n]$ , causing these interest rates to fall further. In this case, banks would prefer to invoke the repo facility and buy the bond from SNDO at a higher rate instead of buying the bond in the market. This implies

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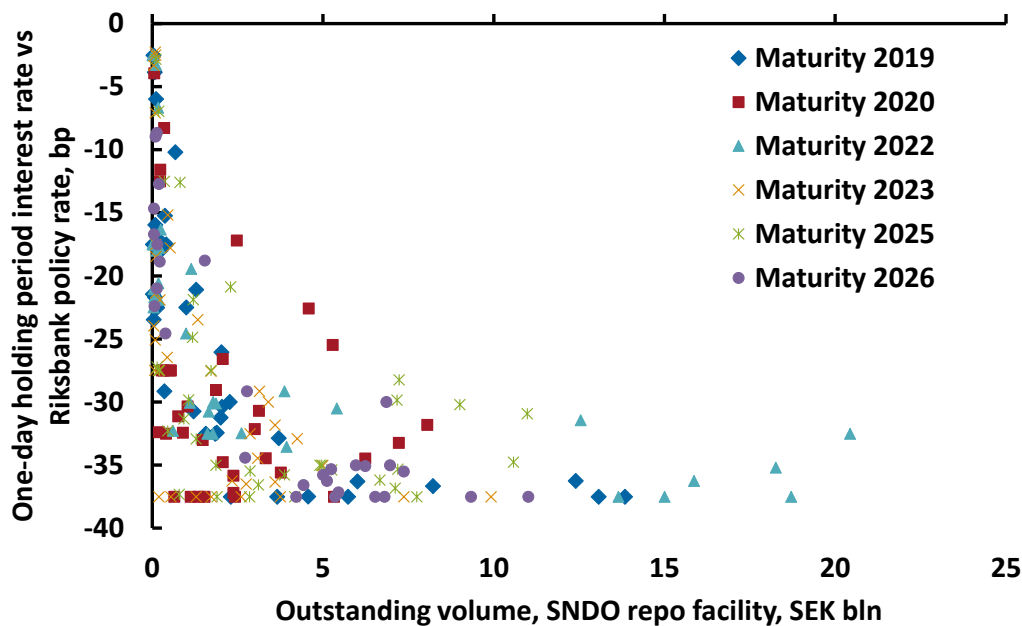
<sup>35</sup> The tenor of these transaction is normally TomNext although SNDO, on demand, also provides bonds Overnight.

<sup>36</sup> Although these transactions formally have a one-day tenor, banks can roll these holdings. Thus, we can say more generally that banks can invest in an arbitrary period in an arbitrary ISIN and receive a floating interest amounting to the Riksbank policy rate minus 0.40 percentage points.

that SNDO endogenously supplies more bonds to the market. This process will continue until market interest rates, for one-day holding periods, are restored to the level of the SNDO repo facility.

Of course, in reality we will never see interest rates fall below a level corresponding to the Riksbank policy rate minus 0.40 percentage points. When interest rates are at this level, we can only observe shifts in the supply of bonds from SNDO preventing interest rates to fall. This process is illustrated in Figure 7, which plots combinations of sell/buy-back interest rates relative the policy rate (i.e. the negative of  $\omega_t^j$  with notations from *equation 1*), and outstanding amounts endogenously supplied through the repo facility during 2015-2017. The dots in Figure 7 seem to be concentrated around the axes. Thus, as expected, the volumes supplied through the repo facility were relatively irresponsive of shifts in offered sell/buy-back interest rates when these rates were close to the Riksbank policy rate. However, from Figure 7, we can also see that there is no single volume associated with an interest rate at the Riksbank policy rate minus 40 basis points. This indicates that purchases from the Riksbank, when interest rates in the government bond market already amounted to the Riksbank policy rate minus 0.40 percentage points, were met by offsetting supplies of bonds by SNDO and thus, we will never observe short interest rates fall below this level. A corollary to this is that the volume of bonds available to the market may decline less than the total scope of a bond purchase programme.<sup>37</sup>

Figure 7. SNDO endogenously responds when interest rates fall far enough<sup>38</sup>



Source: The Riksbank, the Swedish National Debt Office, SNDO and Nordea Markets.

Note. The figure contains data for bonds of  $n$  different ISINs during the  $T$  months between February 2015 and December 2017.

There are thus  $nT$  dots in the figure.

<sup>37</sup> The time series of the volume bonds supplied via the SNDO repo facility is subject to large volatility. Thus, it is difficult to assess to what extent the bonds provided by SNDO offset Riksbank purchases.

<sup>38</sup> In the figure, one-day holding period interest rates and outstanding volumes are monthly averages. Interest rates seem to be slightly above a level corresponding to the Riksbank policy rate minus 40 basis points. However, interest rates are mid prices, i.e. the average of the bid and ask rates. Agents wishing to invest money, i.e. buy first and sell later, will thus face a slightly lower interest rate, closer to 40 basis points below the policy rate. To keep the figure readable, it only contains those bonds that in December 2017 had reached a level close to -40 bp. Unsurprisingly, the two bonds maturing in 2028 and 2039 respectively where the Riksbank only had slim holdings, had very little outstanding volume in the SNDO repo facility. Only for one month did the sum of these two bonds volumes exceed SEK 2 bln.

Let us assume volumes supplied in SNDO's regular auctions reflected the borrowing requirement, expected by SNDO. Then, the endogenous response to Riksbank purchases, manifested in more volumes supplied via the repo facility, constituted an additional borrowing above that required to meet the central government's outlays. If SNDO had invested these additional funds received in private assets, e.g. covered bonds, Riksbank purchases would still have had an effect on inflation and the real economy. However, in 2015-2017, SNDO had access to central bank reserves in the form of Riksbank certificates.<sup>39</sup> SNDO could thus invest funds received from the repo facility in Riksbank certificates, thus mitigating monetary policy effects from bond purchases.

I have now provided evidence on the third proposition in the introduction. At all points in time, SNDO endogenously supplied any government bond preventing its one-day holding period interest rate from falling below the Riksbank policy rate minus 40 basis points. The floor to these short interest rates implied that there was a non-linearity in the relationship between Riksbank's holdings of government bonds and short-term holding period interest rates on these bonds. In addition, since SNDO had access to central bank reserves in the form of Riksbank certificates, there was also a non-linearity between the Riksbank's holdings and effects on the real economy.

Finally, we can note that, if the duration channel is insignificant, i.e. bond purchases do not affect  $\Delta_t^j$  in equation 4 in any material way, then from equation 4 and equation 5, we see that the repo facility also reduces the effect on term premiums from bond purchases.

## Concluding remarks

In this article, I have studied the period 2015-2017 when the Swedish central bank, the Riksbank, acquired a large share of the outstanding stock of nominal government bonds, or more specifically, 44 percent of the outstanding stock of nominal government bonds. I have concluded that non-bank investors met lower short-term interest rates, the larger the share of the outstanding stock of government bonds the Riksbank withheld from the market. Indeed, by the end of 2017, when the policy rate amounted to -0.50 percent, investors faced short-term interest rates in the government bond market at levels close to -0.90 percent! Thus, for a given expected policy rate path, Riksbank purchases had resulted in a more expansionary monetary policy.<sup>40</sup>

I have also concluded that, without further research we do not have solid evidence that government bond purchases, to any significant extent, affect interest rates via a duration risk channel. As regards short-term holding period interest rates on government bonds, purchases seem to affect bonds of different maturities in a similar way. Also, effects on estimated term premiums of e.g. 10-year bonds, seem to be of the same order of magnitude as we would expect to see in the absence of a duration risk channel.

Finally, I have shown that the repo facility provided by the SNDO induces a floor to short-term holding period interest rates on government bonds and consequently there is a non-linearity in the relationship between the Riksbank's holdings of government bonds and short-term holding period

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<sup>39</sup> SNDO reported holdings of Riksbank certificates in the monthly report *Sweden's Central Government Debt*. Since SNDO is not a monetary policy counterparty to the Riksbank, SNDO purchased these securities via a bank that is a monetary policy counterparty to the Riksbank.

<sup>40</sup> In the stylized framework I have outlined in this article, investors only hold government bonds and consequently, the link between interest rates on government bonds and investor's intertemporal choice problems is obvious and direct. In reality, investors can of course hold several asset classes, e.g. risky bonds, money at bank accounts or physical capital. Thus, a more complete assessment of the implications of government bond purchases should also take into account the pass-through from government bond prices to these other asset classes.

interest rates on these bonds.<sup>41</sup> Also, since SNDO, at the time, had access to central bank reserves in the form of Riksbank certificates, the endogenous response from SNDO mitigated the monetary policy effect from Riksbank purchases.

To make the exposition in this staff memo tractable, I have made some deliberate simplifications and omitted some details. Below, I list two of these simplifications. The list could serve as a list of potential subjects for future research.

- This memo only investigates the effect on interest rates of *nominal* government bonds and Riksbank holdings are consistently shown as Riksbank holdings of nominal government bonds. However, in 2016-2017, the Riksbank also accumulated a small portfolio of index-linked bonds.<sup>42</sup> Likely, purchases of index-linked bonds also affect interest rates of nominal government bonds to some degree. However, this channel is not explored in this memo.
- If the Riksbank *permanently* would withhold a large share of the stock of government bonds, it cannot be excluded that the market would eventually find substitutable assets, i.e. the substitutability may be time-dependent. Perhaps this effect is insignificant for the term premiums we examined in the 5 to 10 year segment. The effect of a bond holding could though, to some extent, level off if the Riksbank kept its holdings long enough. Whether this effect exists is not explored in this staff memo.

Finally, I would like to provide a word of caution to those considering studying the endogenous response from SNDO by monitoring *volumes* supplied via the repo facility, and its implications for monetary policy, after 2017. Two factors might have changed.

- Assume SNDO until 2017 supplied nominal bonds in regular auctions in volumes that varied systematically with e.g. total borrowing requirement. By the end of 2017, the Riksbank declared that redemptions and payments from coupons would be reinvested until further notice and consequently, agents including the SNDO probably concluded that Riksbank holdings of nominal government bonds were not transitory. If this would affect nominal auction volumes for a given level of total borrowing, then we can no longer observe the endogenous response from SNDO solely by monitoring *volumes* supplied via the repo facility.<sup>43</sup>
- As regards Riksbank certificates, the Riksbank has since 2017 varied its policy. By introducing caps to the share of central bank reserves that can consist of tradable Riksbank certificates, the amount central bank reserves available to SNDO and other non-bank agents may have declined. If SNDO endogenously responds to Riksbank purchases by more borrowing, SNDO may have to invest the additional funds received in private assets, e.g. in covered bonds. Thus, if SNDO after 2017 endogenously responded to Riksbank purchases, it could still have a monetary policy effect.

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<sup>41</sup> I would like to stress that the SNDO repo facility was introduced long before the Riksbank bond purchase programme. The motive for introducing it was of course not to mitigate effects from potential future Riksbank purchases but to enhance liquidity. The primary dealers of SNDO can always quote offer prices regardless of their own holdings knowing that they can always purchase the bond from SNDO.

<sup>42</sup> In December 2017, the Riksbank bond portfolio consisted of index-linked bonds with a face value of SEK 38 bn.

<sup>43</sup> In this article, I have shown that, given the level of Riksbank holdings at the end of 2017, a lower volume of nominal government bonds available to the market would be met with more bonds supplied via the repo facility. In February 2018, SNDO declared that regular auction volumes had reached a lower limit, and thus would not be lowered regardless of the level of budget surplus. In the report *Central Government Borrowing, Forecast and Analysis 2018:1*, SNDO said one motivation was that a reduction of bond borrowing would "be countered by greater demand for the Debt Office's standing repo facility". One interpretation of this is that SNDO signalled it was willing to supply more nominal bonds for a given level of budget surplus, than normal.

Anyway, the implication of the SNDO repo facility is that SNDO endogenously will supply bonds, (whether in regular auctions or via the repo facility) preventing short holding period interest rates to fall below a certain level.

## References

- Alsterlind J, Erikson H, Sandström M, Vestin D (2015). "How can government bond purchases make monetary policy more expansive?". Riksbank Economic Commentaries. No 12.
- Altavilla C, Carboni G, Motto R (2015). "Asset Purchase Programs and Financial Markets: Lessons from the Euro Area". ECB Working Paper Series. No 1864.
- Andrés, J, López-Salido J. D, Nelson E (2004). "Tobin's Imperfect Asset Substitution in Optimizing General Equilibrium". Journal of Money, Credit and Banking. Vol. 36. No. 4.
- Arrata W, Nguyen B, Rahmouni-Rousseau I, Vari M (2018). "The Scarcity Effect of Quantitative Easing on Repo Rates: Evidence from the Euro Area". IMF Working Paper Series. No 18/258.
- Bailey A, Bridges J, Harrison R, Jones J, Mankodi A (2020). "The Central Bank Balance Sheet as a Policy Tool: Past, present and Future". Bank of England Staff Working Paper. No 899.
- Bank for International Settlements (2019). "Unconventional Monetary Policy Tools: a Cross-Country Analysis". CGFS Papers, No 63.
- Bindseil U (2016). "Evaluating Monetary Policy Operational Frameworks". Jackson Hole Economic Symposium. Kansas Fed.
- Brunnermeier M, Merkel S, Sannikov Y (2020). "Debt as Safe Asset: Mining the Bubble". Preliminary Working Paper.
- Chen H, Curdia V, Ferrero A (2012). "The Macroeconomic Effects of Large-Scale Asset Purchase Programs". The Economic Journal, No 122.
- D'Amico S, Fan R, Kitsul Y (2018). "The scarcity value of Treasury collateral: Repo market effects of security-specific supply and demand factors." Journal of Financial and Quantitative Analysis. Volume 53. Issue 5
- D'Amico S, King T (2013). "Flow and Stock Effects of Large-Scale Treasury Purchases: Evidence on the Importance of Local Supply". Journal of Financial Economics. Elsevier. Vol 108(2).
- De Graeve F, Iversen I (2015). "Central Bank Policy Paths and Market Forward Rates: A Simple Model". Sveriges Riksbank Working Paper. No. 303.
- De Rezende R (2017). "The Interest Rate Effects of Government Bond Purchases away from the Lower Bound. Journal of Money and Finance". Journal of International Money and Finance. Vol 74. Issue C.
- Diez de los Rios A, Shamloo M (2017). "Quantitative Easing and long-Term Yields in Small Open Economies". Staff Working Papers. Bank of Canada.
- Dudley W C (2010). "The Outlook, Policy Choices and our Mandate". Remarks at the Society of American Business Editors and Writers Fall Conference. New York City.
- Ferrari M, Guagliano C, Mazzacurati J (2017). "Collateral Scarcity Premia in Euro Area Repo Markets". ESRB Working paper series, No 55.

Flodén M (2018). "The Riksbank's Balance Sheet: How Large Should it be in the Future". Speech at Swedish House of Finance.

Gagnon J (2016). "Quantitative Easing: An Underappreciated Success". Policy Brief 16-4. Peterson Institute for International Economics.

Harrison R (2012). "Asset Purchase Policy at the Effective Lower Bound for Interest Rates". Bank of England. Working Paper No. 444.

International Capital Market Association, ICMA (2013). "Frequently Asked Questions on Repo". Available on ICMA's web page.

International Capital Market Association, ICMA (2019). "ICMA European Repo Market Survey". No 38. Conducted December 2019.

Krishnamurthy A, Vissing-Jorgensen A (2011). "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy". National Bureau of Economic Research. Working Paper 17555.

Krishnamurthy A, Vissing-Jørgensen A (2012). "The Aggregate Demand for Treasury Debt". Journal of Political Economy. Vol 120.

Jordan B. D. and Jordan S.D. (1997). "Special repo rates: An empirical analysis". The Journal of Finance. Vol 52. No 5

Joyce M. A. S, Miles D, Scott A, Vayanos D. (2012). "Quantitative easing and Unconventional Monetary Policy-an Introduction". The Economic Journal. No 122(564).

Joyce M. A. S, Lasoosa A, Stevens I, Tong M. (2011). "The Financial Market Impact of Quantitative Easing in the United Kingdom". International Journal of Central Banking. Vol 7. Issue 3.

Krishnamurthy A, Vissing-Jorgensen A. (2011). "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy". Working Paper 17555. National Bureau of Economic Research.

McLaren N, Banerjee R. N, Latto D. (2014). "Using Changes in Auction Maturity Sectors to Help Identify the Impact of QE on Gilt Yields". The Economic Journal. Vol 124. No 576. Wiley.

Modigliani F, Sutch R. (1966). "Innovations in Interest-Rate Policy". The American Economic Review Vol 56. No 1/2.

Swedish National Debt Office (2018). "Central Government Borrowing, Forecast and Analysis". 2018:1.

Vayanos D, Vila J-L (2009). "A Preferred-Habitat Model of the Term Structure of Interest Rates". NBER Working Paper Series. Working Paper 15487.

Williams J. C. (2014). "Monetary Policy at the Zero Lower Bound. Putting Theory into Practice". Report. Brookings.

World Bank (2010). Repo Markets : Background Note. Washington, DC. © World Bank.

Yellen, J. (2011): "The Federal Reserve's Asset Purchase Program" Speech at the The Brimmer Policy Forum, Allied Social Science Associations Annual Meeting.



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