Portfolio balance effects of the SNB's bond purchase program*

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Abstract

This paper carries out an empirical investigation of the impact on bond spreads of the announcement, purchases and exit from the SNB's bond purchase program in 2009-2010. We find evidence in favor of a negative effect of the program on the yield spreads of covered bonds. The effect materializes in the days following the announcement of the SNB's intention to buy bonds issued by private sector borrowers, as markets learn that the SNB is buying covered bonds. The specification of the bond spreads used allows us to identify this effect as a discounted portfolio balance effect of the expected purchases, as distinct from policy signalling. In contrast, we find no evidence of a further effect of the actual purchases and subsequent sales on bond spreads.

JEL: E5; G1

Keywords: portfolio balance; credit spread; corporate spread; unconventional monetary policy; central bank asset purchases; credit easing; zero lower bound

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1 Introduction

As policy rates were reduced to the lower bound in early 2009 in many western countries, and the economic outlook called for further monetary stimulus, a number of central banks resorted to using alternative monetary policy tools. Among these were outright asset purchases. The Federal Reserve engaged in large scale asset purchases, in several rounds, starting in late 2008. The Bank of England carried out purchases of Gilts, also in several rounds. The Bank of Japan was engaged in government bond purchases even before the Financial Crisis, and has continued to purchase bonds throughout the crisis period. What is less well known in that the Swiss National Bank (SNB) has also engaged in asset purchases as an unconventional policy measure. In March 2009, the SNB announced its intention to buy bonds by private issuers, after which it bought covered and non-bank corporate bonds directly from the markets. The SNB's bond purchase program is unique in international comparison in that the program has already been exited. Without announcement, the bonds were discretely sold off in 2010. This paper looks at the effect of the announcement of the program, and exploits the variation in the Swiss data on bond purchases and sales to carry out an empirical investigation and identification of the effects of these on Swiss covered and corporate credit spreads.

Central bank asset purchases are argued to affect long-term interest rates mainly through two channels, namely a policy signalling channel (the engagement in asset purchases independently signals something about the central bank's intended future policy stance, which in turn affects expected future policy rates), and the portfolio balance effect (asset purchases change the relative supply of the purchased asset in the market, which under certain assumptions affect relative asset prices).[1] The identification of the specific channel at work is important in light of the exit from asset purchase programs. Thus, if central bank purchases affect yields through policy signalling effects, then there is no reason to expect future asset sales to have an impact on interest rates, provided that expectations and communication are managed well by the central bank. In this case, future asset sales can to some degree be performed independently of the central bank's interest rate target. Conversely, if recent asset purchases have affected interest rates through portfolio balance effects, then future central bank asset sales may increase yields. In this case, an abrupt exit could be highly disruptive for the markets. The path of asset sales would have to be consistent with the central bank's strategy for increasing interest rates.

A large and very active literature investigates the effects and mechanisms of currently active asset purchase programs. Recent examples for the US and UK programs include Gagnon et al. (2010), Hamilton and Wu (2010), Neely (2010) and Joyce et al. (2011). While this literature has made substantial advances in estimating the likely effect of central bank purchases on the yields of the purchased assets, it has proved harder to empirically identify the different channels through which this effect has come about. The predominant approach to identifing the different channels has been to estimate term structure models, noting that portfolio balance effects should affect only term premia, whereas policy signalling effects should affect only the risk neutral part of interest rates (i.e. expected future short rates). However, Bauer and

[1] A third channel, the effect of the expansion of bank reserves on bond yields has also shown to be relevant under certain circumstances, see Krogstrup et al. (2012b). It is, however, less relevant in the context of the Swiss asset purchase program, and we will hence touch on this only briefly below.

Rudebusch (2011) show that the results of estimating term structure models are uncertain and highly dependent on the specific type of model estimated. Accordingly, a consensus on the importance of the different channels has yet to emerge from the literature.

We contribute to this literature by studying the effects of the SNB bond purchase program on bond spreads. Data for the Swiss bond market allows us to compute a model-independent measure of the variation in the issuer-specific term premium for the categories of bonds purchased by the SNB. By matching this variation with the announcement and time profile for the SNB bond purchases, we are able to identify portfolio balance effects.

We find evidence of a significantly negative effect of the bond purchase program on the term premia of covered bonds, suggesting the presence of expected or actual portfolio balance effects. The effect materialized in the days following the announcement of the program, as the markets were learning that the SNB was buying covered bonds. The purchases of covered bonds during the rest of 2009 did not exhibit additional systematic significant effects on the covered bond spread in the daily frequency. We also find no effects on bond spreads of the unannounced exit from the program in 2010 at the daily frequency. One interpretation is that markets fully discounted the expected effect of the purchases and subsequent sales in the days following the onset of the program. This would have required that markets correctly forecasted the SNB's intended purchases and sales, both in terms of volumes and dates, which is unlikely. It is also possible that portfolio balance effects of the actual purchases did occur, but not systematically and at a different frequency than the daily one. In this case, our data and econometric analysis would not allow us to pick it up. Another interpretation is that perceived or expected (as opposed to actual) portfolio balance effects exist, and these only materialize if and when the market is aware of the central bank's actions.

The paper proceeds as follows. Section 2 discusses how central bank purchases of Swiss corporate bonds affects credit spreads in theory, and how we identify these effects empirically. Section 3 describes an index of the credit spread for sub-categories of bonds in the Swiss bond market. This index allows us to isolate the exact component of the term premium which should be expected to be affected by central bank purchases. Section 4 presents the daily data and an event analysis based on the graphical evidence, while Section 5 outlines the econometric approach and provides regression results. The final section concludes and appendix provides details on the construction and sources of the data used.

2 The SNB bond purchase program and identification of its impact

At 2pm on the 12th March 2009, after its regular quarterly monetary policy assessment, the SNB announced that it would engage in purchases of bonds issued by private sector borrowers. A number of other unconventional policy measures were announced in the same press release. The target for the 3M CHF Libor was reduced to 0.25 percent, which was considered the effective zero lower bound, and the targeted Libor fluctuation band was narrowed. More repo operations with longer maturities were announced. Moreover, the SNB announced that it would engage in foreign exchange interventions to prevent further exchange rate appreciation. No information was given about the size of the bond purchase program,

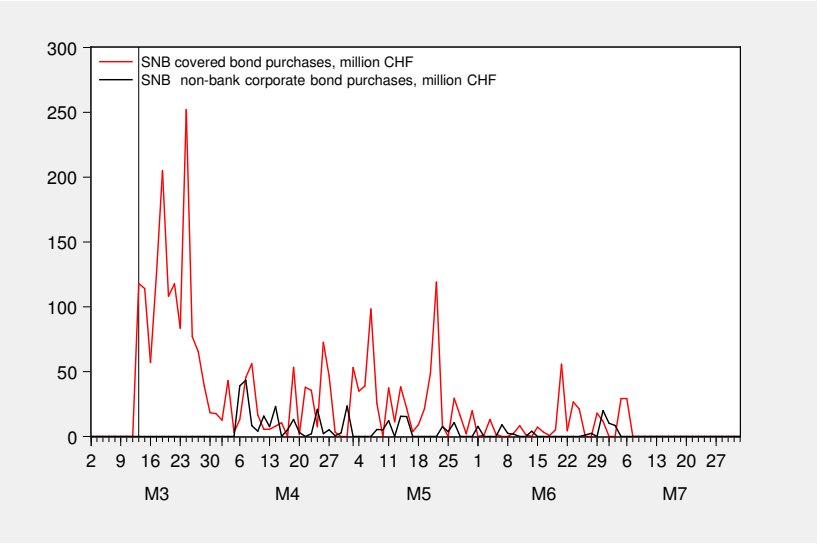

Figure 1: SNB Purchases of bonds issued by private borrowers, in million CHF. 2009

nor was any information given on which types of privately issued bonds would be purchased (covered, corporate).[2] The markets thus had to learn from the subsequent actions taken by the SNB. The SNB started to purchase bonds immediately, i.e. right after 2pm on the 12 March. The vertical line in Figure 1 shows the announcement and date of first purchases on 12 March 2009, and the red and black lines show purchases of covered and corporate bonds respectively. In the first weeks after the announcement, the SNB exclusively bought covered bonds. About three weeks later, on 6 April 2009, the SNB commenced purchases of non-bank corporate bonds in addition to continuing the purchases of covered bonds. Non-bank corporate bond purchases remained a small part of overall purchases throughout the program.

The bond purchases took place at different times of day during the purchase period, and the purchases continued in both bond categories until early July. No further bonds were purchased after July. The purchases were officially discontinued in September 2009, and the program was announced as completed in December 2009.

The program was exited as the bonds were sold back into the market during the months of March to August 2010. This was a period of falling risk aversion and high demand for assets denominated in Swiss francs, notably Swiss bonds. The profile for the bond sales is depicted in Figure 2.

The exit was not announced. The sales were carried out anonymously, and remained largely unnoticed. The first piece of information as to the fact that the SNB was selling off its bonds came in late August 2010 with the release of its monthly balance sheet statistics (monthly bulletin). At this time, nearly all the bond were sold off.

[2] A week later, on the 19th March, 2009, SNB Governing Board Member Thomas Jordan stated in a speech that the purpose of private bond purchases was credit easing, i.e. reduction of risk premia for private borrowers in capital markets.

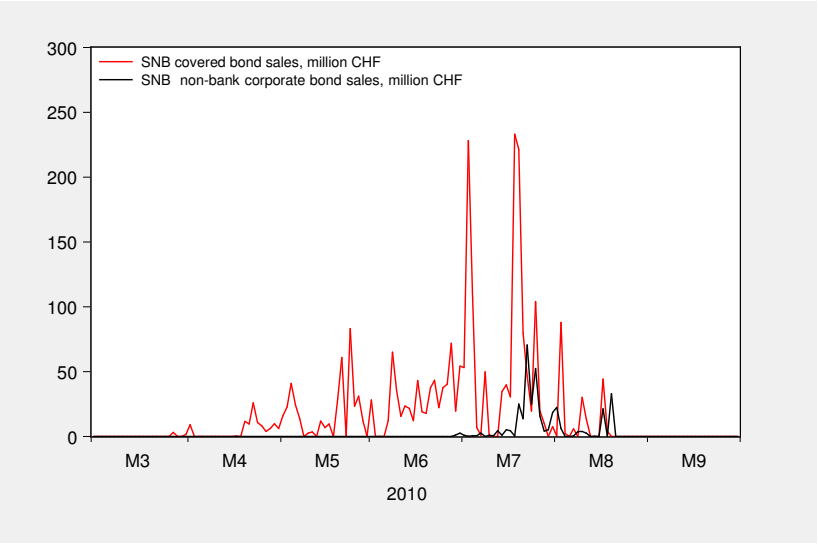

Figure 2: SNB sales of bonds issued by private borrowers, in million CHF. 2010

At the hight of the program, the SNB had purchased a total of about CHF 3 billion worth of assets, or about 0.5% of Swiss GDP, which is small relative to for example the Federal Reserve asset purchase programs (the total assets purchased by the Federal Reserve now exceed 10% of GDP). The program was not small relative to the size of the Swiss bond market, however. At the end of 2009, covered bonds on the balance sheet of the SNB amounted to about 5% of the total market volume of covered bonds at that time, 20% of gross new issuance and 100% of net new issuance of covered bonds in the Swiss market in 2009. The corporate bond purchases were less substantial, both in absolute and in relative terms.

How should we expect the SNB's announcement and subsequent bond purchases to have affected Swiss private sector bond yields? The yield of a bond can be written as consisting of a risk neutral part as given by expected future short interest rates, and a term premium, according to:

$$\imath_{t,j}^{m} = RN_t^m + TPM_t^m + TPI_{t,j}^m \tag{1}$$

where t is time, j is the specific issuer, and m is maturity. RN_t^m is the risk-neutral part of the interest rate. The term TPM_t^m is a macro risk premium, capturing for example uncertainty regarding the growth and inflation outlook, or changes in overall risk aversion. In contrast, $TPI_{t,j}^m$ is an issuer specific risk premium, which depends on issuer specific risks such as the risk of default of the issuer in question, risk aversion, and preferred habitat. Whereas per definition, $TPI_{t,j}^m$ differs across issuers, RN_t^m and TPM_t^m are the same for all bonds in the country in question.

The effect of the bond purchase program on bond yields can be divided into two broad categories, namely the policy signaling effect and the portfolio balance effect discussed in the introduction. First, the SNB bond purchase program could have signalled to the markets something about how the SNB perceived the economic situation and prospects. In turn, the program would have affected the market view of how the SNB intended to set short term

interest rates in the future. Such changes in expected future policy rates would affect RN_t^m. Policy signalling effects could have occurred both at the announcement of the policy, and when the subsequent outright purchases took place, as both types of instances could have contained separate new information.

Second, portfolio balance effects would arise because central bank purchases of bonds directly from the markets would reduce the remaining supply of such bonds in the market. Private portfolios would hence have to adjust. All else equal, a reduction in the supply of a bond would tend to increase the price of that bond relative to the prices of other assets according to theories of portfolio balance (see for example Tobin (1965), Hamilton and Wu (2010) or Vayanos and Vila (2009)). The portfolio balance effect would affect the $TPI_{t,j}^m$ part of the yield. It is possible that the $TPI_{t,j}^m$ of close substitutes to the bonds purchased by the SNB would also be affected through substitution effects.

The portfolio balance effect can occur at announcement and when the actual purchases take place, depending on the level of information that markets have at each of these types of events. If markets know in advance the size of the purchases, the timing and the type of bonds to be purchased, it is reasonable to assume that some, if not all, of the portfolio balance effects will happen instantly, as markets discount the expected change in the price. However, in the case of the SNB bond purchase program, and as opposed to the Federal reserve and Bank of England programs, this information was not revealed with the announcement on the 12th March, nor at any later stage prior to the termination of the program. Markets were hence left to infer from the subsequent actions of the SNB which types of bonds would be purchased and how much. Portfolio effects could hence have occurred both at announcement time, and in connection with the subsequent actual purchases.

Separating the effect of the program into a policy signaling effect which affects risk-neutral rates only, and a portfolio balance effect which affects the term premium only, is of course a convenient simplification which facilitates the empirical analysis. A few potential complications should be noted, however, as they will have to be kept in mind for the specification of the baseline regression and controls.

First, the news that the announcement provided to the markets about the future economic outlook and the seriousness of the situation could also have affected the *uncertainty* about expected future growth and inflation outcomes, which in turn would affect TPM_t^m. This could in turn have increased market risk aversion, which would have affected bonds as a function of their level of risk, and hence, $TPI_{t,j}^m$. Moreover, if markets adjusted their expectations of the economic outlook when the bond purchase program was announced, then this could have affected the expected default risk of certain borrowers more than others, in turn affecting $TPI_{t,j}^m$. These effects through risk aversion and expected default risk have to be kept in mind, as we will need to control for them in our regressions.

The purchase program could also have affected the market liquidity of the purchased bonds, which in turn could have affected their attractiveness and hence price. This market liquidity effect (to be distinguished from the liquidity effect of higher bank reserves) would also affect the issuer specific term premium of the bonds, $TPI_{t,j}^m$. We take this possible market liquidity effect into account in the empirical specification by controlling for a measure of

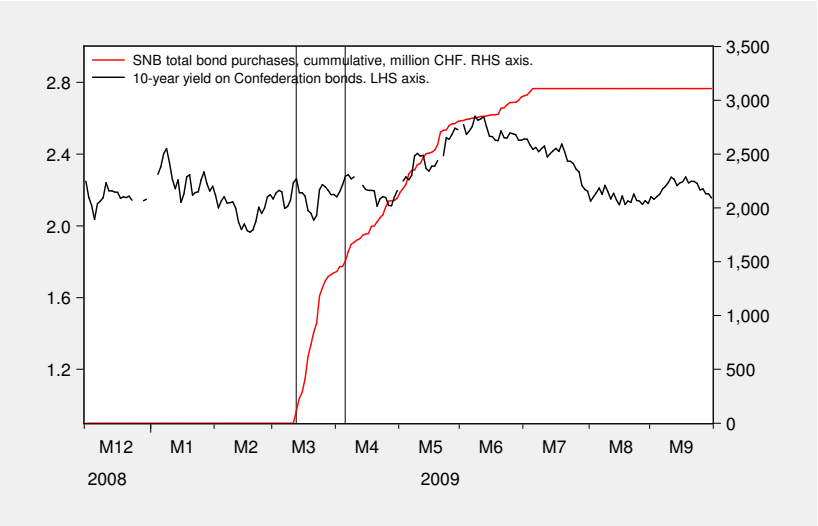

Figure 3: The SNB bond purchases and the 10-year yield on Confederation bonds

market liquidity specific to the categories of the purchased bonds.

Finally, any unsterilized asset purchases by a central bank increases banks' reserves and hence the money supply. In turn, more bank reserves could increase the overall demand for assets from banks, which in turn would tend to increase the price of assets, as argued in Krogstrup et al. (2012b). The effect is referred to as a liquidity effect in the traditional macro literature (see for example Cochrane (1989)). All else equal, the liquidity effect should not discriminate between assets in banks' portfolios. It could hence reduce TPM_t^m, but should not necessarily affect the issuer specific term premium $TPI_{t,j}^m$. One exception is worth mentioning. Empirically, liquidity effects have mainly been found in the yields of highly liquid and safe bonds such as government bonds. It could hence be that the liquidity created by the bond purchases would have had the effect of reducing Confederation bond yields more than the yields of other bonds. If so, this would not be a problem for our identification strategy here, as explained in Section 5.2. Note that there is no reason to expect liquidity effects of the bond purchase program itself to have been important in Switzerland, given the relatively small size of the program, as well as the high level of bank reserves already in the system at this time due to other unconventional policy measures. Just as is the case for the portfolio balance effect, liquidity effects could occur at announcement as well as at the actual bond purchase times, depending on the market's level of information at these events. Except for a fall at the announcement of the policy package on the 12th March 2009, Confederation bond yields did not in fact fall during the period in which the SNB was buying bonds, see Figure 3.

The discussion of the different effects of the bond purchase program implies that if we isolate $TPI_{t,j}^m$ in the data, and associate it with the announcement time of the SNB bond purchase program as well as the dates of the subsequent actual bond purchases, and correctly control for changes in risk aversion, market liquidity and expected default risk, then any remaining significantly negative correlation with the bond purchases or with the announcement of the bond purchase program should indicate portfolio balance effects.

3 A measure of the issuer specific term premium: The credit spread

Based on Equation (1), we compute the issuer specific term premium as the spread of the yield on any individual bond over the yield on the corresponding maturity Confederation bond.

$$\begin{aligned} CS^m_{t,j} &= i^m_{t,j} - i^m_{t,conf} \\ &= TPI^m_{t,j} - TPI^m_{t,conf} \end{aligned} \tag{2}$$

We then assume that $TPI^m_{t,Conf}$ is orthogonal to the SNB's bond purchases. As discussed above, liquidity effects of the bond purchases could affect the Confederation bond specific term premium, but such an effect would only bias our results downward. Apart from liquidity effects, the assumption of an orthogonal $TPI^m_{t,Conf}$ is reasonable in light of the liquid market for Confederation bonds and the very low default risk of these bonds. In order to get a smooth series for the credit spread over time, we take a weighted average of these bond specific term premia across categories of bonds traded in the Swiss bond market, to get credit indices for covered bonds, domestic non-bank corporates, cantonal bonds and bank bonds. The first two are the focus of this analysis. The latter two indices are used for comparison below.

The credit indices are derived from individual bond yield-to-maturity spreads over Swiss Confederation bonds of the same maturity (the latter interpolated using a spline), aggregated according to the emission volume of the bond in question, and across all maturities.[3] Both indices are based on a sufficiently large set of observations for every point in time to be representative of overall market conditions. The resulting series for covered and corporate bonds, as well as an index comprising all bonds in the Swiss bond market, are depicted in Figure 4.

4 Event study approach

The daily credit indices offer interesting insights into how spreads evolved during the period when the SNB bond purchase program was active. We start with an investigation of the onset and purchase period in the spring and summer of 2009.

4.1 The announcement and the bond purchases in 2009

Figures 5 to 9 depict the credit indices of four bond categories together with the SNB bond purchases. The two vertical lines in the Figures denote, first, the announcement of the program and beginning of the covered bond purchases on the 12th March, and second, the onset of the more moderate industrial bond purchases on the 6th April 2009, respectively.

[3]The averaging over different maturities could cause the credit index to be correlated with the average time-to-maturity in the market. However, the mean time-to-maturity shows little variation over time and is never significant in the various regressions we conduct.

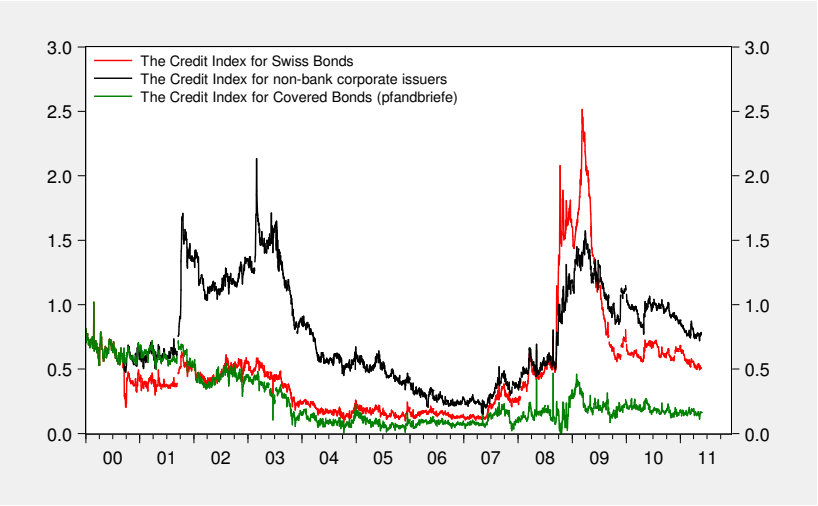

Figure 4: The credit index for total, covered and corporate bonds

Figure 5 shows that there was no visible effect of the SNB announcement on 12th March 2009 on corporate bond spreads. One possible reason could be that market participants did not know what the SNB meant by "bonds of private borrowers" and hence did not react by changing their demand for corporate bonds at announcement. Instead, the corporate credit index started declining on the 2nd April 2009, a few days before the SNB started outright purchases of non-bank corporate bonds on the 6th April. From pure visual inspection, however, it is not clear that this decline was related to the bond purchase program.[4]

Figure 6 shows that the spread on covered bonds at first did not react to the announcement. Zooming in on the weeks surrounding the announcement of the program, Figure 7 shows that the spread remained steady in the days following announcement, i.e. on the 13th and 14th of March. The spread then dropped by about 10bp on the third day, and a few more basis points in the following days, i.e. between the 16th and 19th March 2009.

Neither corporate bond spreads, nor the spreads for cantonal bonds and bank bonds depicted in Figures 8 and 9 saw falling spreads in the days following the SNB announcement. On the contrary, spreads for other bond categories increased. The strong fall in covered bond spreads is hence particular to covered bonds rather than a change in overall market conditions or sentiment.

Rather than a portfolio balance effect, could the drop in the covered credit spread reflect a lower liquidity risk premium due to an increase in market liquidity triggered by the fact that the SNB entered this particular market? This is not likely according to Figure 10. As a proxy for the the daily liquidity of the covered bond market, Figure 10 plots a weighted average of daily bid-ask spreads of the bonds that enter the credit index, together with the covered credit spread and the date for the announcement of the program. A narrower bid-ask

[4]A speech was given by the president of the SNB governing board, Philipp Hildebrand, on the 2nd April 2009, in which he stressed the bond purchase program and what the SNB intended with this program. Whether or not this information was important for the spread is difficult to assess.

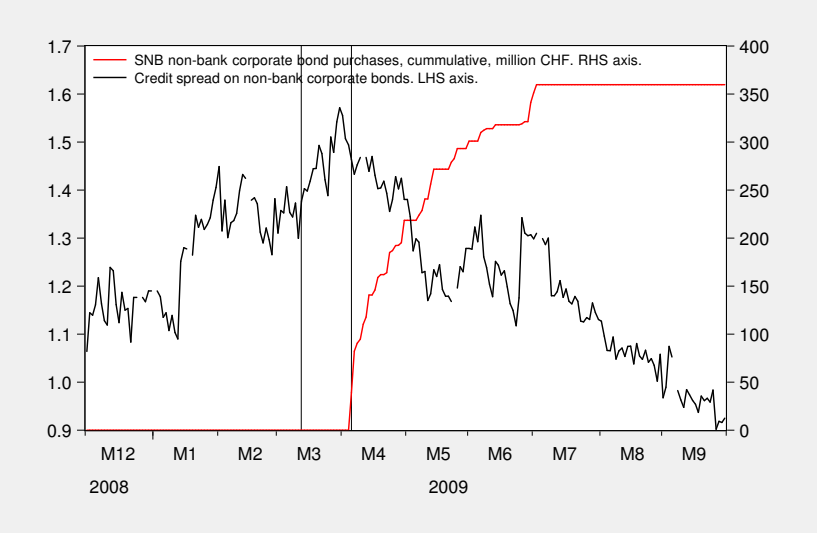

Figure 5: Daily non-bank corporate credit index and cumulated SNB non-bank corporate bond purchases, levels

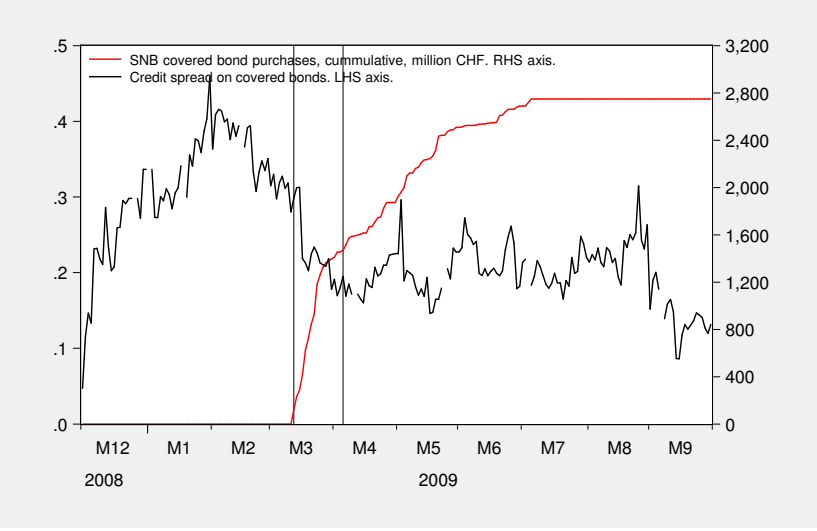

Figure 6: Daily covered bond credit index and the SNB covered bond purchases, levels

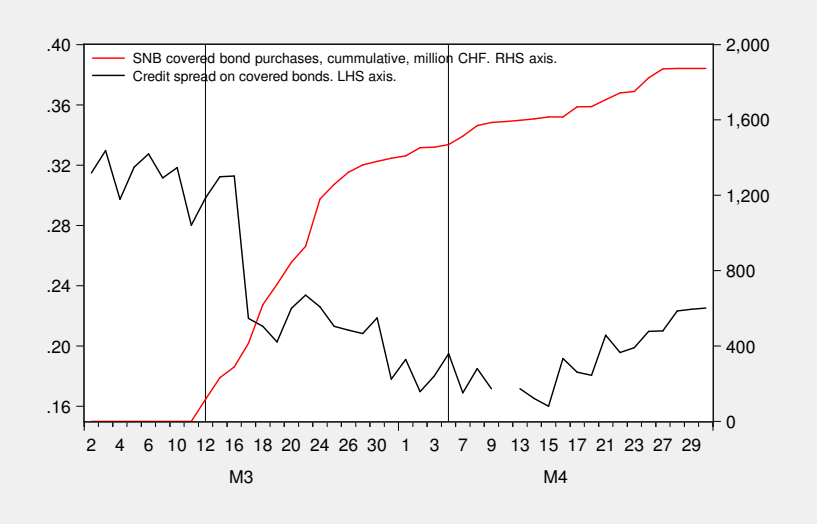

Figure 7: Daily covered bond credit index and the SNB covered bond purchases, levels

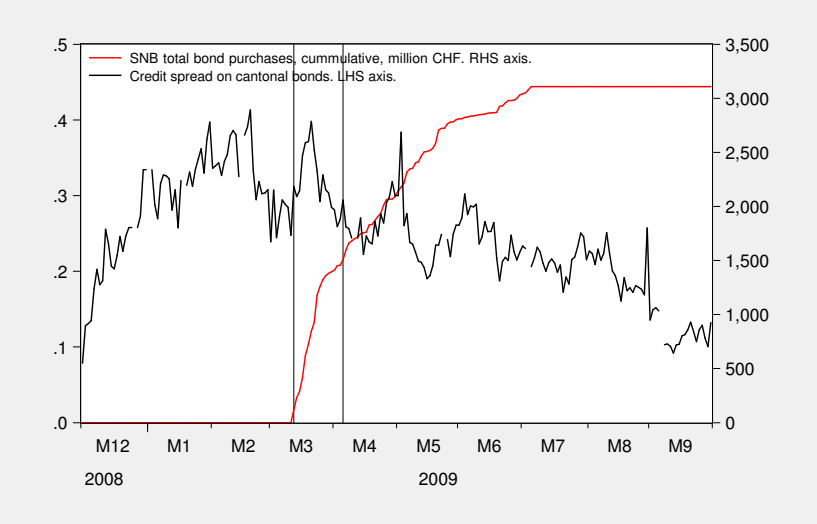

Figure 8: Daily cantonal bond credit index and the SNB total bond purchases, levels

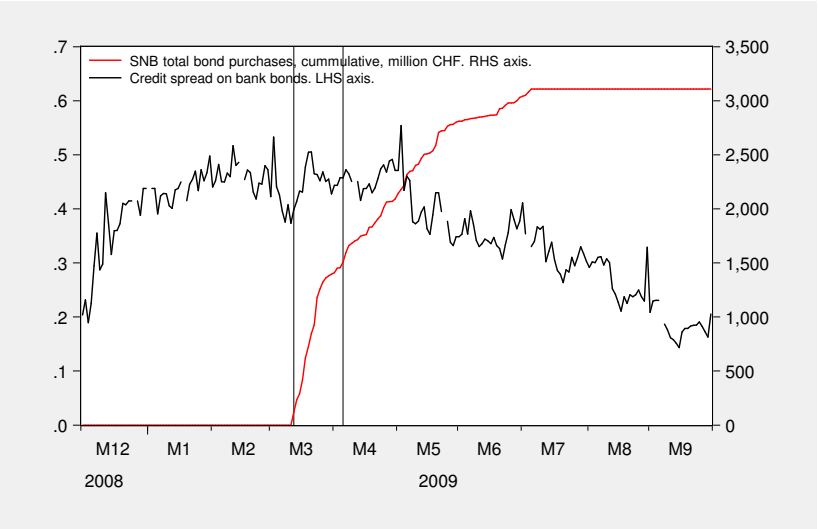

Figure 9: Daily bank bond credit index and the SNB total bond purchases, levels

spread should reflect higher liquidity. If anything, however, market liquidity in the covered bond market seems to have decreased in the days following the announcement of the bond purchase program.

Finally, Figure 11 shows the movement of 10-year Confederation bond yields around the time of the announcement of the SNB bond purchase program. Yields dropped in the days after the announcement, which could reflect changes in all three components of the yield. The drop suggests that the fall in the credit spread on covered bonds in the days after the announcement came in spite of a drop in risk free rates, i.e. covered bond yields fell even more than risk free yields.

4.2 The unannounced bond sales in 2010

Just as for purchases, we would expect the bond sales in 2010 to have had an effect on credit spreads if central bank open market operations have portfolio balance effects. Contrary to the announced purchases, however, we would expect the effects of the unannounced sales to occur as a consequence of the actual sales, rather than being discounted by market participants in an announcement effect. Figures 12 to 13 show the covered and corporate bond credit spreads and the SNB holdings of the corresponding bonds during the period of the sales in 2010 respectively. The Figures show very little sign of an increase in bond spreads as a result of the sales. There is no clear direct reaction of the spread to the sales, and spreads tend to decline rather than increase over the time period.

4.3 Conclusions from the event analysis

The event analysis suggests that when the markets had observed the SNB's purchases of covered bonds in the days following the announcement of the program, the plausible portfolio balance effect of the SNB's total expected purchases was discounted in a decline in the covered bond spread of between 10 and 12 basis points. No such effect was observed in the spread for corporate bonds or any other bond category for that matter. Spreads generally declined in

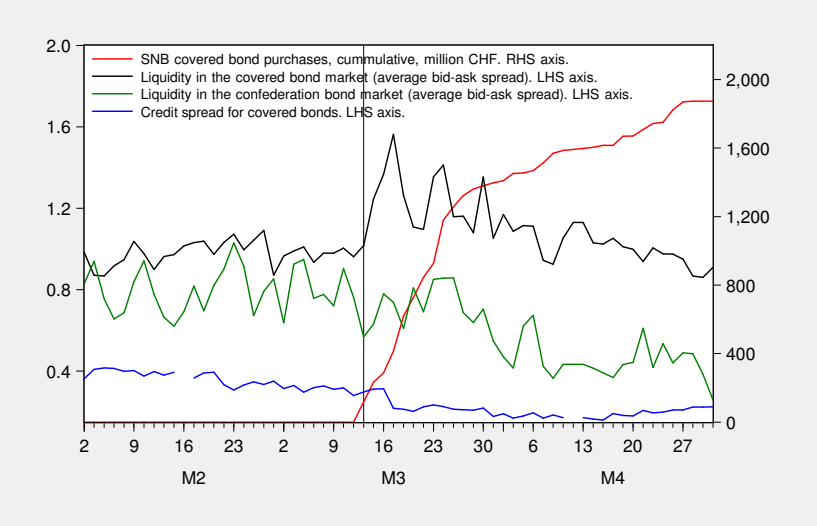

Figure 10: Covered credit spread, market liquidity and SNB bond purchases

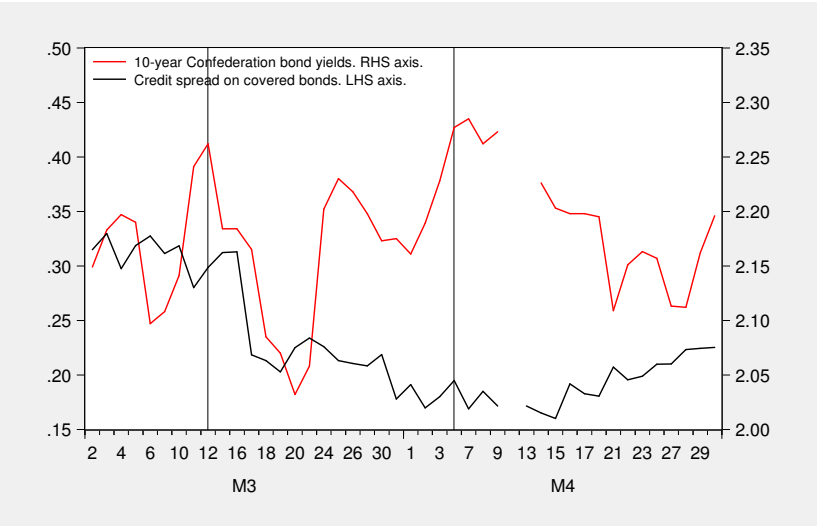

Figure 11: Covered credit spread and Confederation bond yields around the SNB announcement

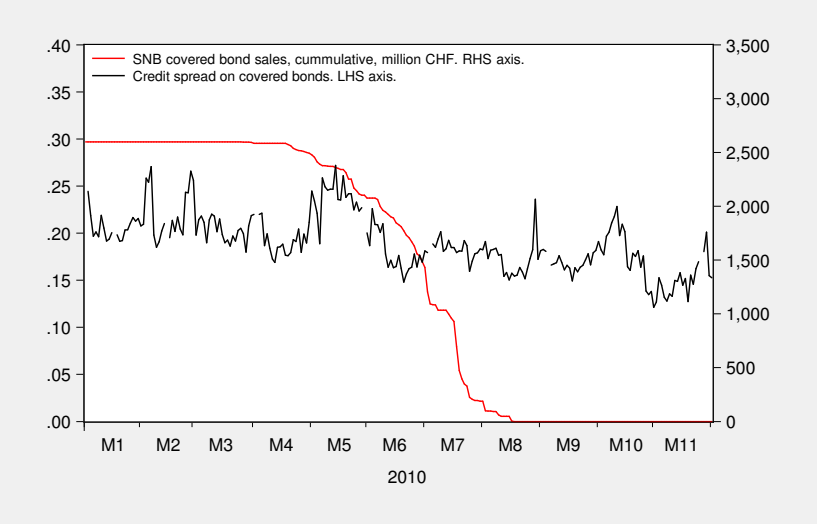

Figure 12: Daily covered credit index and the SNB covered bond sales, levels (holdings)

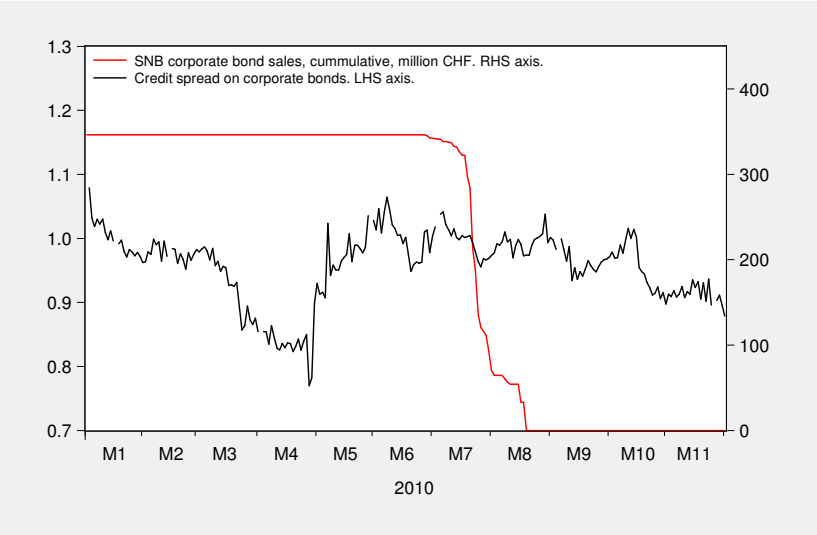

Figure 13: Daily corporate credit index and the SNB corporate bond sales, levels (holdings)

the months following the first purchases, as we would expect from a further portfolio balance effect on spreads. In contrast, spreads also slightly declined during the period of the bond sales, whereas a portfolio balance effect of the sales should generate an increase in spreads. It is hence not clear from the data that portfolio balance effects were present beyond the initial discounted effect in the days following the announcement.

While these visual impressions are suggestive, no firm conclusions can be drawn on causality between the SNB bond purchase program and credit spread from the figures alone.[5] First, we need to investigate whether the decline in the covered spread in the days after the announcement of the program was statistically significant. Moreover, we also need to control for movements in other factors during the period in question. In particular, we need to assess whether the subsequent bond purchases and sales might have had independent effects on credit spreads aside from the announcement, when controlling for the main determinants of Swiss credit spreads. We hence turn to econometric analysis of the bond purchase program.

5 Econometric investigation

We carry out regressions for the credit index for covered and non-bank corporate bonds respectively, on determinants of credit spreads as well as on the SNB bond purchases and sales. The sample period is September 2000 to December 2010. We use daily data, which allows us to carefully assess the effect of the announcement of the program and possible immediate effects of purchases on bond markets. The regressions are estimated in first differences so as to circumvent non-stationarity problems (the credit spread has a unit root, whereas the first difference is stationary). The baseline regression specification is in line with the literature, e.g. Collin-Dufresne et al. (2001) and Avramov et al. (2007). It should be noted that portfolio balance effects of the actual purchases could materialize with a longer delay that what we can allow for in a daily first differences specification. However, it is more difficult to establish causality in levels regressions and regressions using weekly or monthly frequency. We hence only do so as a robustness check. The baseline specification becomes:

$$\begin{aligned}\Delta ci_t =&\alpha + \beta_{vol} vol_t + \beta_{SPI}\Delta SPI_{t-1} + \beta_{snb}\Delta SNBb_t + \beta_{dcov}\Delta D_{t-1}^{snbcov} \\ &+ \beta_{dcorp}\Delta D_{t-1}^{snbcorp} + \beta_{TS}\Delta TS_t + \beta_R \Delta R_t^{10y} + \beta_{BA}\Delta BidAsk_t + u_t, \end{aligned} \tag{3}$$

ci_t is the relevant credit index, and $\Delta SNBb_t$ captures the actual monthly purchases (+) and sales (-) of corporate and covered bonds effected by the SNB in the period between March and December 2010. We include the contemporaneous purchases and sales as well as a lag. The lag is included in order to allow for all purchases or sales that have taken place after the time of the recording of the credit spread (morning) to have an effect on the credit spread the day after. The purchases and sales are measured in percent of the corresponding bond category's emission volumes. D_t^{snbcov} is a dummy for the date of the announcement of the SNB purchase program and the date of the first covered bond purchases. It is included to capture both the effects of the announcement on spreads, and the effects of the markets' learning that

[5] This point is made by Stroebel and Taylor (2009) in a general critique of the event analysis approach to assessing the effects of the various asset purchase programs conducted by the Federal Reserve since the onset of the financial crisis.

the SNB is buying covered bonds. We include three lags of this dummy in the regression using daily data, in order to capture residual movements in covered bond spreads during the days following the announcement. The choice of three daily lags of the announcement dummy allows us to test whether the strong fall in the covered bond spread after three days of the announcement is significant when controlling for other determinants of the spread. We do not include the contemporaneous announcement dummy, because the press release and first purchases were made in the afternoon of the 12th of March, whereas the data used for the calculation of the credit spread is collected in the morning. For consistency, we also include three lags of a second dummy, $D_t^{snbcorp}$, which captures the date of the first corporate bond purchases on the 6th of April 2009. This dummy captures effects on spreads of the markets learning that the SNB has entered the non-bank corporate market.

The control variables are the following. vol_t is the conditional stock price volatility estimated during the sample period, included to control for a link between credit spreads and high volatility periods (risk aversion). SPI_t is a measure of expected loss due to default, which we - following the previous literature - proxy by the log of the level of the main Swiss stock price index, the SPI. Note that the SPI also captures the overall performance of the economy. Volatility and the SPI are lagged one day to account for the fact that the data for these variables are collected at market close while the data on credit spreads are collected during the morning. All other daily variables are collected during the morning, and hence included as contemporary variables only.

In order to control for changes in market liquidity around the announcement and purchase times, we include the average emission-volume-weighted bid-ask spread of the bond category in question less the average emission-volume-weighted bid-ask spread for confederation bonds. The bid-ask spread is based on data on bid and ask prices from the same daily dataset on the Swiss bond market used to compute the credit index. The average bid-ask spreads are hence consistent with the credit index in terms of types of bonds included in the different categories, the time of day at which the data are collected in the market, and how it relates to the confederation bond market. The liquidity measure is described in Krogstrup et al. (2012a).

Macroeconomic developments are further controlled for by including the long term interest rate level, i.e. the 10-year Confederation bond yield R_t^{10y}. Its empirical prior is negative (see Collin-Dufresne et al. (2001)). A higher level of interest rates reflects a strong business cycle developments, which is good for firm profitability. Finally, we follow Fama and French (1989) and include the term spread, TS_t, defined as the difference between the 10-year Confederation bond yield and the three-month CHF libor. A higher term spread could be taken to signal higher uncertainty about future economic outcomes, suggesting a positive relation with credit spreads.

5.1 Regression results

Table 1 presents the results for the baseline regression using daily data for covered and non-bank corporate spreads in column one and two. Most control variables have the correct signs, and the term spread and the long-term bond yield are significant.

Confirming the visual impressions of Section 4, the third lag of the announcement and purchases dummy for covered bonds is significantly negative in the covered bond spread regression, suggesting that the spread declined by about 10-12 basis points on that day without any of the control variables included in the regression being able to account for that. The decline is significantly different from zero at the 1% level. It is hence plausible that it is the result of the markets' evolving perception regarding the SNB intentions of purchasing covered bonds.

The results also confirm that the announcement did not affect corporate bonds to the same degree. The second lag after announcement is significantly negative, while the third lag is positive. None of the estimated parameters for the lags are of an economically relevant size. The same lack of economic relevance holds true for the dummy for the beginning of the corporate bond purchases on the 6th April 2009.

Turning to the parameter estimates for the outright bond purchases and sales of the SNB, these come with the expected negative sign, but they are insignificant in both regressions. The data thus does not support the hypothesis that there were additional immediate portfolio balance effects associated with the outright purchases and sales. Using a dummy taking the value one from January 2010 onwards, the specification in Table 2 allows the effects of the purchases and the effects of the sales in 2010 to differ. Again, neither the purchases nor the sales have significant effects on credit spreads.

The lack of an effect of the outright bond market interventions could reflect the efficient markets hypothesis that the effect of the purchases was discounted in the price of covered bonds as soon as the markets has realized that the SNB would be buying covered bonds. This interpretation implies that markets know what the aggregate portfolio balance effect of the purchases would be, without knowing how much and for how long the SNB intended to buy, which seems unlikely. Alternatively, the lack of an effect of the interventions would also be consistent with the view that markets discounted an expected effect of the interventions, which didn't actually materialize.

In conclusion, the data supports the hypothesis that there was an announcement effect of the first covered bond purchases on the spreads of covered bonds. However, there is no evidence in the data of an economically relevant effect of the bond purchase program on corporate bonds.

5.2 Robustness

Tables 4 to 8 display the results of a series of robustness tests. First, the bond traders at the SNB are likely to have adjusted their purchases according to the market conditions of the purchased bonds. For example, it is possible that covered bonds were purchased at a larger quantity on days where prices of these were going down and yields up, as it was the intention of the SNB to reduce the yield spreads. Similarly, it is likely that more bonds were sold on days when the prices of the bonds were increasing and yields falling, during the sales period in 2010. This suggests a source of endogneity of the SNB's bond market interventions which would tend to bias the parameter estimates of the regressions downward. There are two ways

of addressing this type of endogeneity in the literature (see references to investigations of the ECB's SMP, non-published papers). One way is to investigate intra-day high-frequency data. We do not have intra-day data on credit spreads. The second option is to use instruments. We are not aware of any good instrumental variable for SNB bond market interventions. As a second-best option, we carry out a TSLS regression using lags of the explanatory variables as instruments. We instrument bond purchases and sales and their first lag with their 2nd and 3rd lags. The results are given in Table 3. As could be expected, standard errors increase strongly, but all coefficients that stay significant keep the right sign. The conclusions from using instruments are largely the same as those from standard regressions. The actual bond purchases and sales did not systematically affect credit spreads. In lack of appropriate instruments, however, it is not possible to make any firm conclusions on the lack of an effect.

Second, Table 4 shows that a longer average maturity of outstanding total bonds is found to significantly reduce the covered credit spread. However, the inclusion of average maturity does not affect the conclusions from the baseline regressions. It should be added that no redemptions or new issues of covered bonds took place during the week after the announcements of the bond purchase program, and hence, that there was no exceptional variation in the average maturity in those days.

Third, in the months and year after the announcement of the SNB bond purchase program, corporate spreads generally declined in western countries. This was a period of increasing calm in global financial markets. Could the decline in the covered spread following the announcement of the bond purchase program have reflected a more general decline in international corporate spreads? Table 5 shows that controlling for movements in different types of US and European corporate spreads do not change the findings. The foreign spreads used here are not even significant in explaining daily changes in Swiss covered and corporate spreads.

Fourth, Table 6 shows the regression results when controlling for the market liquidity of the purchased bonds. The results confirm the conclusions derived from Figure 10. The average bid-ask spread as a proxy for market liquidity is not significant and its inclusion does not change the finding that the covered credit spread fell significantly in the days following the announcement.

Fifth, Table 7 uses a different proxy for risk aversion, namely the spread between the 3-month Libor and the 3-month term overnight interest swap rate. The change of control variable is inconsequential for the significance of the relevant parameter estimates.

Further, the distribution of credit spreads tend to have fat tails. We hence allow for time varying variation by estimating a Garch(1,1) specification using maximum likelihood techniques. The GARCH specification becomes:

$$\begin{aligned}\Delta ci_t =&\alpha + \beta_\sigma \sigma_t^2 + \beta_{SPI}\Delta SPI_{t-1} + \beta_{snb}\Delta SNBb_t + \beta_{dcov}\Delta D_{t-1}^{snbcov} \\ &+ \beta_{dcorp}\Delta D_{t-1}^{snbcorp} + \beta_{TS}\Delta TS_t + \beta_R \Delta R_t^{10y} + \beta_{BA}\Delta BidAsk_t + u_t, \end{aligned} \tag{4}$$

$$\sigma_t^2 = \omega + \alpha u_{t-1}^2 + \beta \sigma_{t-1}^2, \tag{5}$$

$$u_t|\mathcal{F}_{t-1} \sim \mathcal{N}(0, \sigma_t^2), \tag{6}$$

where $\mathcal{F}_{t-1}$ is the information set in period t-1. Results for the estimation of this specification, given in Table 8, confirm the results from the baseline specification.

Finally, the lack of significance of the actual bond purchases and sales in the credit spread regressions could be taken to reflect the daily frequency of the data used and/or the use of first differences. We find that this is not the case. In regressions in levels, with and without a lagged dependent, the outright purchases and sales remain largely insignificant (not shown).[6]

6 Conclusions

This paper has investigated the impact of the SNB bond purchase program of 2009-2010 on Swiss corporate spreads, and found evidence suggesting a moderate effect of the announcement of the bond purchases on the credit spreads of covered bonds in the order of about 10-12 basis points. The effect materialized in the days following the announcement of the program and first bond purchases. Subsequent actual bond purchases had no further effect on spreads. Moreover, there was no evidence in the data of an effect of the program on corporate bond spreads. Finally, the unannounced bond sales in 2010 did not affect the spreads of the sold bond categories. Markets were not aware of the sales until they were largely over, and the bonds were sold off during a period of low risk aversion and high demand for bonds.

The design of the empirical investigation allows us to plausibly identify the announcement effect on covered spreads as the market discounting an expected portfolio balance effect of the SNB bond purchases. It also allows us to characterize the effect as a lower bound for the total effect of the bond purchase program on bond yields. Thus, the actual bond purchases could have had portfolio balance effects on spreads beyond those we identify, if, for example, such effects materialized with a delay of more than a few days, of if the effects on spreads were irregular, for example due to variable lags. The data and our empirical strategy does not allow us to pick up such delayed or irregular effects. In addition, the bond purchase program could have had signaling effects on expected future policy and short term interest rates. Signalling effects would not appear in the spreads we investigate, but rather in yields directly. The data we use does not allow us to identify such effects.

The findings suggest more generally that central bank asset purchases programs are probably perceived by the market as having portfolio balance effects, whether or not such portfolio balance mechanisms are really active. These expected effects are then discounted in the prices of the purchased assets at announcement and/or at the onset of the purchase program, depending on the level of information offered at the announcement of the program. One

[6]There is an exception, in that the outright corporate bond purchases turn significant in some specifications. But when this is the case, the contemporaneous and lagged effects cancel out. Moreover, the finding is not robust. The results from the levels regressions show clear signs of misspecification, with high autocorrelation and very instable parameter estimates. Results from the levels regressions are available from the authors.

implication is that the way in which bond purchase programs and their exit are announced and communicated is central to the effect the central bank achieves.

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7 Appendix: The data

7.1 Source and description of the data

The data source for all data used in this analysis is the SNB.

7.2 Volatility data

The conditional volatility used in the analysis is obtained by estimating a standard $GARCH(1,1)$ model on the daily log-returns of the SPI.

7.3 Average rating index

We combine rating classes from different sources. The following order is used, where later sources act as substitutes if the previous ones are unavailable:

1. Standard & Poor's
2. Moody's
3. Fitch
4. Zuercher Kantonalbank

For the average rating index, we had to translate qualitative rating criteria into quantitative information. This is accomplished by numbering consecutively through all rating categories as shown in Table 10 and taking an emission volume weighted average of the resulting values. This conversion is valid given the assumption that differences in credibility between adjacent rating categories are approximately constant.

Table 1: Baseline regression results

	Covered Bonds	Corporate Bonds
	(1)	(2)
$\Delta SNBb_t^{cov}$	1.032	
	(.695)	
$\Delta SNBb_{t-1}^{cov}$	-.652	
	(.782)	
$\Delta SNBb_t^{corp}$		-1.442
		(4.849)
$\Delta SNBb_{t-1}^{corp}$		1.449
		(4.628)
$\Delta vol_{t-1} \cdot 100$	-.149	-.105
	(.171)	(.261)
$\Delta \log SPI_{t-1}$	-.053	-.032
	(.040)	(.069)
ΔTS_t	.094	.146
	(.032)***	(.054)***
ΔR_t^{10y}	-.195	-.381
	(.033)***	(.058)***
$\Delta BidAsk_t$	.002	.004
	(.003)	(.005)
D_{t-1}^{snbcov}	.002	.002
	(.002)	(.004)
D_{t-2}^{snbcov}	.001	-.006
	(.002)	(.002)***
D_{t-3}^{snbcov}	-.098	.017
	(.002)***	(.002)***
$D_{t-1}^{snbcorp}$	-.027	-.030
	(.001)***	(.009)***
$D_{t-2}^{snbcorp}$	.012	.010
	(.001)***	(.011)
$D_{t-3}^{snbcorp}$	-.011	.019
	(.001)***	(.002)***
Const.	.000	.000
	(.000)	(.001)
Obs.	2307	2302
R^2	.058	.079

Notes: The sample period is September 1st, 2000, until December 31th, 2010. The numbers in parentheses are heteroskedasticity- and autocorrelation-consistent (Newey-West) standard errors.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Baseline with an interaction dummy for bond sales

	Covered Bonds	Corporate Bonds
	(1)	(2)
$\Delta SNBb_t^{cov}$	.902	
	(1.121)	
$\Delta SNBb_{t-1}^{cov}$	-.487	
	(1.104)	
$\Delta SNBb_t^{cov} \times Sale_t$	.223	
	(1.424)	
$\Delta SNBb_{t-1}^{cov} \times Sale_{t-1}$	-.308	
	(1.578)	
$\Delta SNBb_t^{corp}$		-4.782
		(7.358)
$\Delta SNBb_{t-1}^{corp}$		-1.966
		(10.305)
$\Delta SNBb_t^{corp} \times Sale_t$		6.841
		(7.483)
$\Delta SNBb_{t-1}^{corp} \times Sale_{t-1}$		4.013
		(10.546)
D_{t-1}^{snbcov}	.001	.002
	(.003)	(.004)
D_{t-2}^{snbcov}	.000	-.006
	(.003)	(.002)***
D_{t-3}^{snbcov}	-.098	.017
	(.003)***	(.002)***
$D_{t-1}^{snbcorp}$	-.027	-.011
	(.001)***	(.019)
$D_{t-2}^{snbcorp}$	.012	.021
	(.001)***	(.026)
$D_{t-3}^{snbcorp}$	-.011	.021
	(.002)***	(.004)***
Obs.	2307	2302
R^2	.058	.079

Notes: The sample period is September 1st, 2000, until December 31th, 2010. The numbers in parentheses are heteroskedasticity- and autocorrelation-consistent (Newey-West) standard errors.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: TSLS regression

	Covered Bonds	Corporate Bonds
	(1)	(2)
$\Delta SNBb_t^{cov}$	-44.896	
	(112.803)	
$\Delta SNBb_{t-1}^{cov}$	39.911	
	(102.295)	
$\Delta SNBb_t^{corp}$		30.824
		(42.181)
$\Delta SNBb_{t-1}^{corp}$		-27.126
		(40.102)
D_{t-1}^{snbcov}	.014	.002
	(.026)	(.004)
D_{t-2}^{snbcov}	-.056	-.006
	(.149)	(.002)***
D_{t-3}^{snbcov}	-.001	.017
	(.233)	(.002)***
$D_{t-1}^{snbcorp}$	.017	-.047
	(.107)	(.022)**
$D_{t-2}^{snbcorp}$	.033	.074
	(.049)	(.091)
$D_{t-3}^{snbcorp}$	-.054	.026
	(.109)	(.011)**
Obs.	2129	2124
R^2	.055	.075

Notes: The sample period is September 1st, 2000, until December 31th, 2010. The numbers in parentheses are heteroskedasticity and autocorrelation consistent (Newey-West) standard errors.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Controlling for the average maturity of the bonds within the given category

	Covered Bonds	Corporate Bonds
	(1)	(2)
$\Delta SNBb_t^{cov}$	1.006	
	(.695)	
$\Delta SNBb_{t-1}^{cov}$	-.654	
	(.777)	
$\Delta SNBb_t^{corp}$		-1.442
		(4.845)
$\Delta SNBb_{t-1}^{corp}$		1.433
		(4.635)
$\Delta vol_{t-1} \cdot 100$	-.148	-.105
	(.170)	(.261)
$\Delta \log SPI_{t-1}$	-.052	-.032
	(.040)	(.069)
ΔTS_t	.092	.147
	(.033)***	(.054)***
ΔR_t^{10y}	-.193	-.381
	(.033)***	(.058)***
$\Delta BidAsk_t$	.002	.004
	(.003)	(.005)
$\Delta \log Mat_t^{pf}$	-.771	.088
	(.289)***	(.415)
D_{t-1}^{snbcov}	.002	.002
	(.002)	(.004)
D_{t-2}^{snbcov}	.001	-.006
	(.002)	(.002)***
D_{t-3}^{snbcov}	-.098	.017
	(.002)***	(.002)***
$D_{t-1}^{snbcorp}$	-.027	-.029
	(.001)***	(.009)***
$D_{t-2}^{snbcorp}$	.011	.010
	(.001)***	(.011)
$D_{t-3}^{snbcorp}$	-.012	.019
	(.001)***	(.002)***
Const.	.000	.000
	(.000)	(.001)
Obs.	2307	2302
R^2	.059	.079

Notes: The sample period is September 1st, 2000, until December 31th, 2010. The numbers in parentheses are heteroskedasticity and autocorrelation consistent (Newey-West) standard errors.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Controlling for foreign spreads

	Covered Bonds	Corporate Bonds
	(1)	(2)
$\Delta SNBb_t^{cov}$	1.281	
	(.746)*	
$\Delta SNBb_{t-1}^{cov}$	-.707	
	(.799)	
$\Delta SNBb_t^{corp}$		-1.054
		(4.705)
$\Delta SNBb_{t-1}^{corp}$		1.092
		(4.729)
$\Delta vol_{t-1} \cdot 100$	-.155	-.114
	(.182)	(.257)
$\Delta \log SPI_{t-1}$	-.044	-.009
	(.040)	(.075)
ΔTS_t	.093	.144
	(.032)***	(.055)***
ΔR_t^{10y}	-.194	-.376
	(.033)***	(.058)***
$\Delta BidAsk_t$	.003	.004
	(.003)	(.005)
$\Delta CorpHL_t^{us}$	-.022	-.012
	(.018)	(.017)
$\Delta CorpHL_t^{eu}$	.022	.043
	(.015)	(.030)
D_{t-1}^{snbcov}	.004	.003
	(.003)	(.004)
D_{t-2}^{snbcov}	.012	.000
	(.009)	(.008)
D_{t-3}^{snbcov}	-.095	.019
	(.004)***	(.004)***
$D_{t-1}^{snbcorp}$	-.028	-.029
	(.001)***	(.008)***
$D_{t-2}^{snbcorp}$	.012	.012
	(.001)***	(.012)
$D_{t-3}^{snbcorp}$	-.013	.018
	(.002)***	(.002)***
Const.	.000	.000
	(.000)	(.001)
Obs.	2307	2302
R^2	.061	.082

Notes: The sample period is September 1st, 2000, until December 318th, 2010. The numbers in parentheses are heteroskedasticity and autocorrelation consistent (Newey-West) standard errors.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Including liquidity measures for Confederation, Covered and Corporate bonds separately

	Covered Bonds	Corporate Bonds
	(1)	(2)
$\Delta SNBb_t^{cov}$	.992	
	(.699)	
$\Delta SNBb_{t-1}^{cov}$	-.708	
	(.783)	
$\Delta SNBb_t^{corp}$		-1.482
		(4.880)
$\Delta SNBb_{t-1}^{corp}$		1.509
		(4.630)
$\Delta vol_{t-1} \cdot 100$	-.153	-.120
	(.172)	(.264)
$\Delta \log SPI_{t-1}$	-.055	-.039
	(.040)	(.070)
ΔTS_t	.088	.157
	(.037)**	(.056)***
ΔR_t^{10y}	-.176	-.383
	(.037)***	(.060)***
$\Delta BidAsk_t^{cov}$	-.007	.000
	(.006)	(.004)
$\Delta BidAsk_t^{conf}$	.000	-.002
	(.005)	(.008)
D_{t-1}^{snbcov}	.005	.002
	(.003)*	(.004)
D_{t-2}^{snbcov}	.002	-.006
	(.002)	(.002)**
D_{t-3}^{snbcov}	-.096	.017
	(.002)***	(.002)***
$D_{t-1}^{snbcorp}$	-.028	-.030
	(.002)***	(.009)***
$D_{t-2}^{snbcorp}$	.012	.010
	(.001)***	(.011)
$D_{t-3}^{snbcorp}$	-.011	.018
	(.002)***	(.002)***
Const.	.000	.000
	(.000)	(.001)
Obs.	2179	2179
R^2	.051	.077

Notes: The sample period is September 1st, 2000, until December 31th, 2010. The numbers in parentheses are heteroskedasticity and autocorrelation consistent (Newey-West) standard errors.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Controlling for LibTois

	Covered Bonds	Corporate Bonds
	(1)	(2)
$\Delta SNBb_t^{cov}$	.846	
	(.725)	
$\Delta SNBb_{t-1}^{cov}$	-.622	
	(.784)	
$\Delta SNBb_t^{corp}$		-.707
		(4.910)
$\Delta SNBb_{t-1}^{corp}$		-.249
		(4.794)
$\Delta LibTois_{t-1} \cdot 100$	.039	.033
	(.027)	(.037)
$\Delta \log SPI_{t-1}$	-.053	-.015
	(.041)	(.071)
ΔTS_t	.079	.134
	(.031)**	(.052)**
ΔR_t^{10y}	-.177	-.371
	(.031)***	(.056)***
$\Delta BidAsk_t$	.003	.004
	(.003)	(.006)
D_{t-1}^{snbcov}	.004	.002
	(.002)*	(.003)
D_{t-2}^{snbcov}	.003	-.004
	(.002)	(.002)**
D_{t-3}^{snbcov}	-.096	.017
	(.002)***	(.002)***
$D_{t-1}^{snbcorp}$	-.027	-.027
	(.001)***	(.010)***
$D_{t-2}^{snbcorp}$	.014	.015
	(.001)***	(.012)
$D_{t-3}^{snbcorp}$	-.011	.019
	(.001)***	(.002)***
Const.	.000	.000
	(.000)	(.001)
Obs.	2167	2162
R^2	.06	.082

Notes: The sample period is September 1st, 2000, until December 31th, 2010. The numbers in parentheses are heteroskedasticity and autocorrelation consistent (Newey-West) standard errors.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: GARCH estimates: conditional volatility (OIM)

	Covered Bonds	Corporate Bonds
	(1)	(2)
$\Delta SNBb_t^{cov}$	1.201	
	(.823)	
$\Delta SNBb_{t-1}^{cov}$	-1.257	
	(.841)	
$\Delta SNBb_t^{corp}$		-1.226
		(3.759)
$\Delta SNBb_{t-1}^{corp}$		3.599
		(3.473)
$\hat{\sigma}^2$	-.030	-.041
	(.050)	(.037)
$\Delta \log SPI_{t-1}$	-.022	-.064
	(.033)	(.045)
ΔTS_t	.045	.102
	(.023)*	(.036)***
ΔR_t^{10y}	-.126	-.308
	(.024)***	(.037)***
$\Delta BidAsk_t$	.001	.002
	(.002)	(.003)
D_{t-1}^{snbcov}	.006	.009
	(.014)	(.031)
D_{t-2}^{snbcov}	.002	-.003
	(.014)	(.015)
D_{t-3}^{snbcov}	-.098	.019
	(.013)***	(.014)
$D_{t-1}^{snbcorp}$	-.027	-.035
	(.011)**	(.017)**
$D_{t-2}^{snbcorp}$	.013	.005
	(.010)	(.015)
$D_{t-3}^{snbcorp}$	-.011	.018
	(.009)	(.011)
Const.	.001	.001
	(.001)	(.001)
α	.349	.468
	(.057)***	(.103)***
β	.541	.621
	(.095)***	(.135)***
ω	.000	.000
	(.000)*	(.000)
df	4.416	2.781
	(.398)***	(.165)***
Obs.	2307	2302

Notes: The sample period is September 1st, 2000, until December 31th, 2010. The numbers in parentheses are observed information matrix standard errors.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Data

Acronym	Explanation
ci_t	Credit index total. Based on bond data collected daily between 9 and 11am.
ci_t^{ind}	Credit index non-bank corporate issuers.
ci_t^{pf}	Credit index covered bonds.
$BidAsk_t^{pf}$	Average emissions-weighted bid-ask spread in the market for covered bonds less that for confederation bonds. SNB-internal computations.
$BidAsk_t^{ind}$	Average emissions-weighted bid-ask spread in the market for non-bank corporate bonds less that for confederation bonds. SNB-internal computations.
$CorpHL_t^j$	Spread between BBB and AAA rated corporate debt, $j = EU, US$.(add source)
D_t^{snb}	Dummy for the zero lower bound period (zero before 17 March 2009, 1 afterwards).
$LibTois_t$	Spread between Swiss 3M Libor and TOIS. 3M Libor is collected daily at 11am in London (12am in Zürich).TOIS is collected at 11am in Zürich.
Mat_t	Mean time-to-maturity of outstanding bonds. Based on bond data collected daily between 9 and 11am.
R_t^{10y}	Zero coupon yield on 10 year government bond. Based on bond data collected daily between 9 and 11am.
Rat_t	Mean rating of outstanding bonds. Based on bond data collected daily between 9 and 11am.
$SNBb_t$	Cumulated purchases of bonds by the SNB, market value, in percent of emissions volume.
$SNBb_t^{ind}$	Cumulated purchases of non-bank corporate bonds by the SNB, market value, in percent of emissions volume.
$SNBb_t^{pf}$	Cumulated purchases of covered bonds by the SNB, market value, in percent of emissions volume.
SPI_t	Total returns on the Swiss Performance Index. Collected daily at market close.
TS_t	Term spread between 10 year and 2 year zero coupon yields on government bonds. Based on data collected between 9am and 11am daily.
VIX_t^{CH}	VIX, implicit 30 days ahead option based volatility of SPI. Collected daily at market close.
VIX_t^{US}	VIX for the US, Chicago board of exchange.
vol_t	Conditional volatility of the SPI, $GARCH(1,1)$. Based on data collected daily at market close.

Table 10: Conversion of rating categories

Rating categories		**Number**
AAA	Aaa	1
AA^+	Aa1	2
AA	Aa2	3
AA^-	Aa3	4
A^+	A1	5
A	A2	6
A^-	A3	7
BBB^+	Baa1	8
BBB	Baa2	9
BBB^-	Baa3	10
BB^+	Ba1	11
BB	Ba2	12
BB^-	Ba3	13
B^+	B1	14
B	B2	15
B^-	B3	16
CCC^+	Caa1	17
CCC	Caa2	18
CCC^-	Caa3	19
CC	Ca	20
C		21
D		22