Liquidity premiums in the Swedish inflation-indexed government bond market

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The breakeven inflation rate, or the difference between nominal and inflation-indexed interest rates, has become an important source of information for central banks to gauge inflation expectations. However, studies have found that the breakeven inflation rate is affected by risk premiums such as liquidity and inflation risk, which if not addressed may distort its information value for inflation expectations. In this article, I address this issue by computing a measure of the liquidity premium in the Swedish inflation-indexed government bond market. The results show that the estimated liquidity premium explains a sizeable portion of the variability in the breakeven inflation rate and tends to increase during periods of heightened financial stress. By correcting the breakeven inflation for the existence of risk premiums I obtain a more accurate estimate of the market's true inflation expectations, available daily.

1 Introduction

As the markets for inflation-indexed bonds have grown in size, the interest rates on these bonds have become an increasingly important source of information about the general state of the economy. By purchasing this type of instruments, investors are able to eliminate the inflation risk embedded in nominal fixed-income securities, and to obtain a given real rate of return regardless of the inflation rate. Interestingly, the spread between nominal and inflation-indexed (real) bond rates of the same maturity – also known as breakeven inflation – measures market participants' inflation expectations for different horizons. Due to its availability in high frequency, several horizons and with a relatively long time history, the breakeven inflation rate has become an attractive measure of inflation expectations compared to other measures such as surveys, which are typically available at much lower frequencies and for fewer horizons.

Although markets for inflation-indexed bonds have grown significantly since their creation, they are still much smaller in size than their nominal counterparts. This creates liquidity issues, which tend to be exacerbated during episodes of financial stress, when investors desire to hold more liquid assets. As discussed by Shen (2006), Pflueger and Viceira (2016), D'Amico et al. (2014), among others, investors therefore typically tend to demand an extra premium for holding these less-liquid bonds – a so called liquidity premium – which tend to be time-varying and higher in periods of market stress. Hence, if the liquidity premium is not accounted for, it may distort the information value of the breakeven inflation rate as a measure of inflation expectations. To address this problem a number of studies have used regression analysis or term structure models to obtain an estimate of a time-

* I would like to thank Jan Alsterlind, Rafael B. De Rezende, Henrik Erikson, Jesper Lindé and Ola Melander for valuable comments, and the Swedish National Debt Office for their permission to use data of the daily transactions in the repo facility. The opinions expressed in this article are the sole responsibility of the author. They should not be interpreted as reflecting the views of Sveriges Riksbank.

varying liquidity premium for inflation-indexed bonds. By removing the estimated liquidity premium from the breakeven inflation rate (together with the inflation risk premium that is commonly embedded in nominal interest rates), central banks can obtain more accurate estimates of inflation expectations from financial instruments.

The aim of this article is to estimate a measure of the liquidity premium in the Swedish inflation-indexed government bond market, and thereby to obtain a better measure of inflation expectations based on a corrected breakeven inflation rate. To the best of my knowledge, this is the first study which attempts to estimate the liquidity premium in the Swedish government bond market.

Following Pflueger and Viceira (2016), I estimate a measure of the liquidity premium using regression analysis. More specifically, I regress the breakeven inflation rate on observable proxies for liquidity in the inflation-indexed bond market, while also controlling for inflation expectations and inflation risk[1]. From the estimated regression I construct a liquidity measure that is used to correct the breakeven inflation for the distortions caused by the liquidity risk premium. The results show that the liquidity measure can explain a sizeable portion of the variability in the breakeven rate. The estimated liquidity premium is time-varying, and increases during periods of heightened financial stress such as the financial crisis of 2008 and the European debt crisis. After correcting the breakeven inflation rate for the liquidity premium and inflation risk, the adjusted series is generally more in line with the level of market participants' inflation expectations as measured by surveys. Since survey measures should not suffer from liquidity issues, this suggests that it can be misleading to use the unadjusted breakeven inflation as a measure of inflation expectations without correcting for the liquidity premium.

The outline for the rest of this article is as follows. I will start with a closer discussion of the liquidity premium, including a motivation of the liquidity variables used later in the study and the estimation strategy. The chosen liquidity measures will then be regressed onto breakeven inflation, while controlling for inflation expectations and inflation risk. The results from this regression is then used to compute the liquidity premium, which is used to calculate the breakeven inflation adjusted for liquidity issues. Next, I compare the unadjusted and adjusted breakeven inflation rates with survey measures of inflation expectations. Finally, I provide some concluding remarks.

2 Liquidity premium

2.1 Estimating the liquidity differential between inflation-indexed and nominal bond yields

An inflation-indexed bond is a bond protecting the investor from fluctuations in inflation, since the cash flows are indexed to the consumer price index. These bonds give the investor a fixed real interest rate plus a compensation for the actual CPI inflation over the maturity of the bond. The difference between a constant maturity zero-coupon nominal and inflation-indexed bond yield is the breakeven inflation rate. This is the rate which would offer the investor the same total return on both bonds, given that inflation averages the breakeven rate over the maturity of the bonds.

1 In order to control for inflation risk I add an inflation risk proxy consisting of the distribution of survey responses on inflation expectations, (for more details please see section 2.3.2). The estimated inflation risk premium has a mean of 0 bps and it does not seem to affect the estimation of the breakeven inflation during the chosen sample period, as shown by the preferred specification (5) in Table 1. Therefore, the focus in this article will be mainly on the liquidity premium.

The breakeven inflation should reflect investors' inflation expectations plus a time-varying compensation for bearing inflation risk.[2] However, the typically smaller size of the inflation-indexed bond market relative to its nominal counterpart has induced the appearance of liquidity issues, which tend to be more prominent during periods of market stress, complicating the interpretation of the breakeven as a measure of inflation expectations. To get compensation for the extra search friction the investors may encounter when selling the inflation-indexed bonds, they demand a liquidity premium in their interest rates, or equivalently a discount in their price. As discussed by Shen (2006), Pflueger and Viceira (2016), D'Amico et al. (2014), among others, it is essential to account for the lower liquidity of inflation-indexed bonds when using them to measure inflation expectations. Since the Swedish inflation-indexed bond market was first created in 1994, it has always been smaller in size than the nominal government bond market, which indicates that there could be a liquidity premium in the interest rates of the inflation-indexed bonds relative to their nominal counterparts.

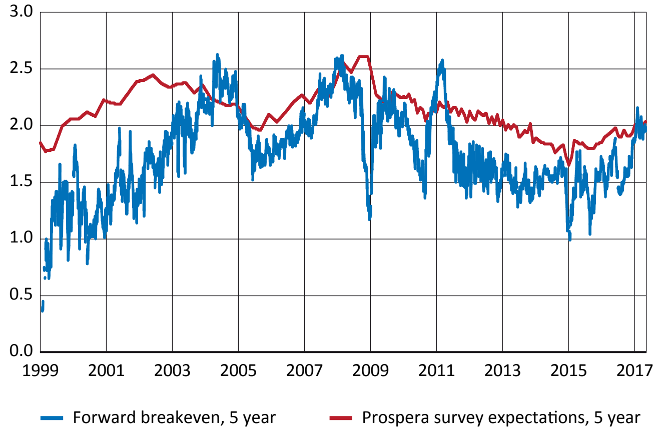
Taking these two risk premiums into account, the breakeven inflation can then be expressed as follows:

BEI = inflation expectations + inflation risk – liquidity premium

The liquidity premium, if positive, will tend to push up the interest rates of the inflation-indexed bonds relative to the ones for the nominal bonds, and tend to lower the breakeven inflation. The possible existence of a positive liquidity premium may explain the difference between breakeven inflation and inflation expectations measured by surveys. Figure 1 shows five-year inflation expectations as measured by the breakeven inflation rate and surveys. As can be seen, the breakeven is persistently lower than the survey expectations. Although surveys may still be an imperfect measure of inflation expectations, due to issues such as measurement errors,[3] the persistent difference between the two measures of inflation expectations suggests that the breakeven inflation may be plagued by the existence of liquidity and inflation risk premium.

Figure 1. Markets participants' five-year inflation expectations as measured by forward breakeven inflation rates and the Prospera survey

Per cent



Sources: Sveriges Riksbank and TNS Sifo Prospera

2 Studies using US data have found the inflation risk premium to be positive, when looking over a longer time period, while studies based on the more recent periods have found evidence of small and slightly negative inflation risk premiums, coinciding with the financial crisis. Looking at the theory, Kitsul and Wright (2013) suggest that the inflation risk premium tends to be positive and large when there is a risk of hyperinflation, but negative when deflation risks are prominent. For more studies on the inflation risk premium, see for example Abrahams et al. (2013), Grishchenko and Huang (2013), D'Amico et al. (2014).

3 For example, the survey's sample of respondents and their responses may not necessarily be representative of the true overall expectations of economic agents. Another problem arises from the fact that there might be different respondents available on each occasion the survey is conducted.

2.2 Estimating the liquidity differential between inflation-indexed and nominal bond yields

The liquidity premium is estimated by regressing the breakeven inflation onto observable measures of liquidity in the inflation-indexed market, while controlling for inflation expectations, following Pflueger and Viceira (2016) and Gürkaynak, Sack and Wright (2010). In order to control for inflation risk, a proxy for the inflation risk premium is also included. The breakeven inflation can then be explained as a function of the following factors:

(1) $$BEI_{n,t} = \alpha_1 + a_2\pi_t^e + a_3\delta_t + a_4X_t + \varepsilon_t,$$

where $BEI_{n,t}$ is the breakeven inflation, π_t^e is a measure of inflation expectations, δ_t is a proxy for the inflation risk premium, and X_t a vector of liquidity proxies.

The estimated liquidity premium is the negative in the variation of $BEI_{n,t}$, explained by the liquidity variables:

(2) $$\hat{L}_{n,t} = -\hat{a}_4X_t.$$

The adjusted breakeven inflation is then estimated as follows:

(3) $$BEI_{n,t}^{adj} = BEI_{n,t} + \hat{L}_{n,t} - a_3\delta_t.$$

2.3 Data

In this section the variables that are used for the regression analysis are presented and discussed. I will start by briefly discussing the interest rate data used to measure the breakeven inflation rate. Thereafter I will proceed with a discussion of the measures used to control for inflation expectations and inflation risk. Finally, the selected liquidity variables for capturing liquidity in the Swedish inflation-indexed market will be introduced and discussed more in detail.[4]

The regressions are estimated using daily data. When data only exists in lower frequency, the series have been interpolated. The sample ranges from 4 January 1999 to 28 April 2017, but since data for some of the liquidity measures are only available for a more recent period, some regressions are estimated using a shorter sample.

2.3.1 Interest rate data

In this study I focus on the five-year forward breakeven inflation rate. One natural reason for that is that central banks are often interested in measuring whether long-term inflation expectations are anchored. Moreover, by using bond rates with longer maturities, any impact of the indexation lag and CPI seasonality, which tend to be a more prominent problem in shorter inflation-index bond rates, should be alleviated. One additional reason for using longer term maturities is that there are generally few outstanding bond contracts in the short end of the inflation indexed yield curve, which implies that the estimated series of the interest rates for these bonds tend to be very volatile and suffer from large fitting errors. I compute the forward breakeven rate using the model suggested by Svensson (1994) to calculate nominal and inflation indexed zero-coupon interest rates. Forward rates are used in order to match the inflation expectations measured from surveys, as explained below.

4 Earlier studies of the liquidity premium in the US government bond market have, for instance, used transaction volumes, fitting errors, the nominal off-the-run spread, bid-ask spreads, and the spread between an inflation swap and the breakeven of the same maturity as proxies to capture the relative illiquidity of US TIPS. Relative transaction volumes and the fitting errors will also be used in this study, while the other variables are not applicable to the Swedish case. Instead a set of new variables, suitable to capture the liquidity in the Swedish inflation-indexed bond market will be introduced.

2.3.2 Measures of inflation expectations and inflation risk

In order to control for inflation expectations, I use the survey on five-year average inflation expectations provided by TNS Sifo Prospera. Prospera ask the participants about their expectations for inflation five years ahead,[5] which is consistent with what is captured by the five-year forward breakeven inflation rate.[6] The respondents consist of labour market parties, purchasing managers and money market players.[7] Up until September 2009, the survey was conducted only on a quarterly-basis. Since then Prospera have started publishing inflation expectations among money market players also on a monthly frequency. To obtain a longer history on inflation expectations, the series before 2009 has been interpolated from quarterly data.

I use the difference between the minimum and the maximum survey responses for the five-year inflation expectations as a proxy for inflation risk in the five-year forward breakeven rate. This is motivated by the fact that the dispersion among responses is likely to be higher when there is a high degree of uncertainty regarding future inflation (see Wright 2011).

2.4 Liquidity variables

2.4.1 Average fitting errors from the Nelson-Siegel-Svensson yield curve estimations

The Riksbank uses the Svensson (1994) method to estimate daily yield curves for a set of debt securities, including government bonds. From these estimations it is possible to also obtain the average daily fitting errors. As discussed by Abrahams et al. (2016), D'Amico et al. (2014), Hu et al. (2013), among others, large fitting errors can be a sign of stress in the market and investors' inability to take advantage of the arbitrage opportunities that appear due to mispricing when investors start behaving irrationally. As such the fitting errors have been described in the literature to be a good proxy for capturing liquidity crises in markets. For this study the daily root mean squared estimation error for the inflation-indexed bond curve, smoothed over the past 20 trading days, will be used. The series is missing data for a set of dates during the crises periods of 2008–2009 and 2011–2012, which implies that there are some gaps in the series that will persist even concerning the estimated liquidity premium. As can be seen in Figure 2a, the series spiked significantly during the financial crisis and then again during the European debt crisis, when investors ran away from less-liquid assets.

2.4.2 Relative transaction volumes

Relative transaction volumes is a measure that has been frequently used in earlier studies as a good proxy for capturing the differential liquidity between inflation-indexed and nominal government bonds.[8] The idea is that very liquid markets tend to have a high turnover, which improves investors' ease of trading by lowering search frictions. This in turn leads investors to ask for a lower liquidity premium. This time series is constructed as the 20-day moving average of the daily secondary market transaction volumes in inflation-indexed government bonds, divided by the corresponding transaction volumes in nominal bonds. The data is

5 From 1995 to 2001, Prospera published the average for inflation expectations in the coming five years. Since most of the regressions in this study are run using a sample that starts from 2001 or later, any impacts from the difference in the calculation of the inflation expectations by Prospera on the results of this study should be negligible.

6 If spot yields were to be used they would capture the expectations up to five years, and thus not be comparable to the question asked in the Prospera survey.

7 The amount of participants approached has varied over the years. In the quarterly survey in June 2018, among all participants, around 200 organisations/companies were approached. In the monthly surveys, conducted only with money market players, around 40–60 organisations have generally been approached.

8 See for example Pflueger and Viceira (2016), D'Amico et al. (2014), Abrahams et al. (2016).

obtained from the Riksbank's database SELMA. As can be seen in Figure 2b, this measure remained relatively low up until 2009. It has then increased somewhat, especially in recent years.

2.4.3 Use of the Debt office's repo facility for inflation-indexed bonds

The Swedish National Debt Office has written agreements with a set of banks to act as the primary dealers in the Swedish government bond market.[9] The primary dealers have to participate in the bond auctions announced by the Debt Office, and thereafter act as distributors of the government bonds at the secondary market. This implies that potential buyers of government bonds always can turn to the primary dealers to receive a price for a bond. In order to reduce the risk of shortages in the government bond market, the Debt Office offers primary dealers the possibility to borrow government bonds through a repo facility. This means that if primary dealers are selling a bond which they currently lack they can always borrow a similar bond from the Debt Office.[10] A lower liquidity in the secondary market, implying a shortage of bonds to be traded, could then lead to a higher use of the repo facility, especially during times of increased financial stress.

The time series used in this study is constructed as the 20-day moving average of the daily transaction volumes of inflation-indexed bonds in the repo facility. The data is obtained from the National Debt Office. Notably the series shows a sharp spike during the financial crisis. The values for this series have then again increased in recent times, which is likely a result of the Riksbank's purchases of inflation-indexed bonds that started in 2016.

2.4.4 Volatility Index (VIX)

The Chicago Board Options Exchange's Volatility Index (VIX) measures the level of market expectations for 30-days volatility of the S&P 500 Index, as implied in the bid/ask quotations of SPX options.[11] It is a commonly used measure of market risk. VIX is obtained from Bloomberg.

VIX is included in the regressions in order to capture investors' variation in risk attitude over time towards any given liquidity risk. The intention with incorporating a risk measure in the model is to capture periods of increased market stress, with large flight-to-safety flows into more liquid instruments, such as nominal government bonds. During such periods the liquidity premium investors require for holding less-liquid instruments, such as inflation-indexed bonds, are likely to be higher (see e.g. Söderlind 2011). The coefficient for VIX in the regression will capture the part of risks that are related to the breakeven inflation, which are inflation risk and liquidity risk. Since I will control for inflation risk in the regressions, the part of risk left which this coefficient is capturing is the liquidity risk.

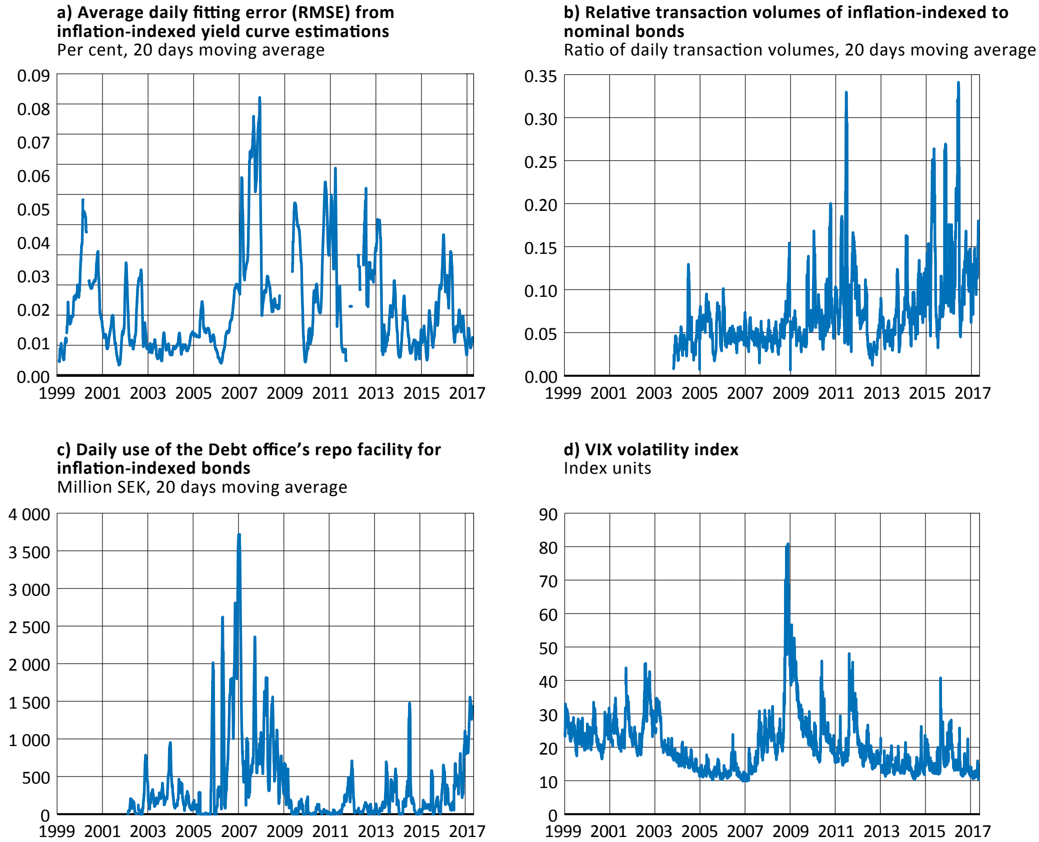
The liquidity variables are plotted in Figure 2d below. As can be seen in the graphs some of the liquidity variables spiked during the financial crisis period of 2008–2009, and during the European debt crisis in 2010–2011, indicating some intensified stress in the market for inflation-indexed bonds during these periods.

9 For a list of the primary dealers, see the Debt Office's website: https://www.riksgalden.se/en/For-investors/Government-securities/Primary-dealers/.

10 For a deeper discussion on the repo facility, see Arvidsson et al. (2003).

11 A deeper definition on the construction of VIX can be found at CBOE's homepage: http://www.cboe.com/vix.

Figure 2. Liquidity variables



Note. The gaps in the series in figure 2a) are due to missing data for the fitting errors during these dates.
Sources: Sveriges Riksbank, the National Debt Office and Bloomberg

3 Results

3.1 Liquidity risk premium in the breakeven inflation rate

Table 1 shows the results from the estimations of the liquidity proxies onto the breakeven inflation rate, while controlling for inflation expectations and inflation risk, in accordance with equation (1). The liquidity proxies are added to the regression one at a time. Regression (5) is the preferred regression where all the liquidity proxies and the control variables are included. It is also this regression, which will later be used to compute the measure of the liquidity risk premium. Regressions (6) and (7) verify the robustness of the results by excluding the financial crisis from the sample.[12]

12 This is done by excluding the period 1 August 2008 to 2 August 2009 from the sample and re-running the regressions.

Table 1. Regressing breakeven inflation on measures of liquidity

Dependent variable: 5-year forward breakeven							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample start	04/01/99	04/01/99	04/01/99	29/01/02	03/11/03	04/01/99 – 31/07/08	03/11/03 – 31/07/08
Sample end	28/04/17	28/04/17	28/04/17	28/04/17	28/04/17	03/08/09 – 28/04/17	03/08/09 – 28/04/17
VIX		−0.02** (0.00)	−0.02** (0.00)	−0.01** (0.00)	−0.01** (0.00)		−0.01** (0.00)
Fitting error, inflation indexed curve			4.65** (0.86)	4.21** (0.67)	2.38** (0.67)		1.58** (0.68)
Repo facility, inflation indexed				−0.00 (0.00)	−0.00** (0.00)		−0.00* (0.00)
Relative transaction volume					0.40* (0.17)		0.53** (0.17)
Survey inflation 5 year	0.95** (0.07)	1.32** (0.07)	1.31** (0.06)	1.27** (0.06)	1.58** (0.06)	1.03** (0.07)	1.67** (0.06)
Inflation risk premium	−0.11** (0.02)	−0.05* (0.02)	−0.05* (0.02)	−0.01 (0.01)	−0.01 (0.01)	−0.10** (0.07)	−0.01 (0.01)
No. of observations	4563	4445	4151	3436	3011	4313	2899
Adjusted R^2	0.33	0.42	0.48	0.55	0.68	0.35	0.69

Note. Numbers within parenthesis shows HAC adjusted standard errors.
* and ** denotes significance at the 5% and 1% levels, respectively.

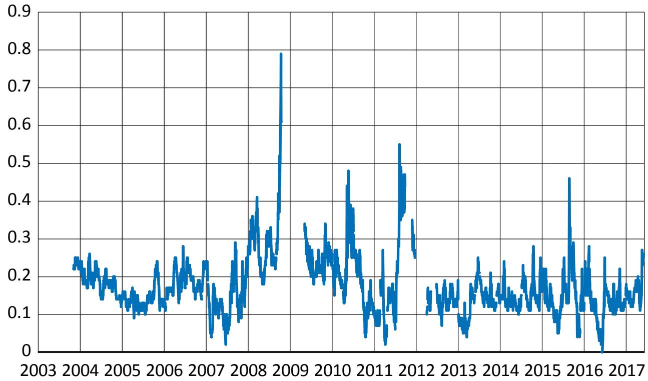
Regression (1) shows that inflation expectations as measured by surveys and the inflation risk proxy jointly explain about 33 percent of the variation in breakeven inflation. The explanation power of the model increases for each additional liquidity variable that is added and the adjusted R^2 reaches 68 per cent in the preferred regression (5), which indicates that observable measures of liquidity explain a sizeable part of the variation in breakeven inflation.

The majority of the coefficients are statistically significant, with signs that follow economic intuition. VIX enters the regression with a negative sign, suggesting, as expected, that the liquidity premium tends to increase in periods where the risk aversion among investors to any given liquidity risk rises. When the fitting errors are added to the regression, the adjusted R^2 increases to 48 per cent suggesting that this series contains important information on the variation in breakeven, such as the importance of funding constraints and investors' inability to take advantage of mispricing during periods where liquidity becomes more scarce. The coefficient for the use of the repo facility for inflation-indexed bonds is negative, and signals that a higher use of the repo facility coincides with a higher liquidity premium. This is in line with expectations, as a higher use of the repo facility may be caused by a scarcity of bonds available to be traded in the secondary market, leading the primary dealers to instead turn to the Debt Office to borrow the bonds they need for their clients. Finally, when the relative transaction volumes are added to the regression, the adjusted R^2 increases by 13 percentage points. The positive coefficient for this variable goes in line with intuition, as a higher traded volume of inflation-indexed bonds leads to less search friction for investors and thereby lowers the liquidity premium they demand for holding these less-liquid bonds. One consideration to make is that some coefficients seem to change values as new variables are included in the regression. One possible explanation for this is that some variables show some correlation between them. As can be noticed from Table A1, inflation expectations according to surveys show a correlation with all the liquidity variables. For example, the correlation with VIX, relative transaction volume and the repo facility is 0.40, −0.38 and 0.31, respectively. This may explain why the coefficients change in all specifications, in particular for the survey variable. In addition, the repo facility shows a correlation of −0.40 with the inflation risk proxy, which may explain the change in the coefficient and the significance of the inflation risk proxy in regression (4). Nevertheless, despite this we can see that the adjusted R^2 of regressions (1) to (5) increases as each liquidity variable is added, which indicates that each of them contains relevant information on the variability of the breakeven inflation.[13]

Figure 3 shows the estimated liquidity premium based on the fitted values from the preferred regression (5).[14] The estimated liquidity premium has a mean of 17 bps. It spiked in 2008 during the financial crisis, similar to other studies (see e.g. Pflueger and Viceira, 2016, D'Amico et al., 2014, Gürkaynack et al., 2010). It also reached higher levels during the European debt crisis in 2010 and 2011, when the risk attitude among investors to any given liquidity risk again turned more negative. The spike in 2015 coincides with the Chinese stock market turmoil, and a period when there was a general flight to safer assets in financial markets.

Figure 3. The estimated liquidity premium

Per cent



Note. The gaps in the series are due to missing data for the fitting errors during these dates.

Figure 4 plots the adjusted breakeven together with survey expectations and the unadjusted breakeven. The adjusted breakeven is corrected for both the liquidity premium and the inflation risk premium,[15] according to the relation in equation 3. After having corrected for these two premiums, the adjusted breakeven is more in line with the level of market participants' inflation expectations, as measured by the Prospera survey. In addition, one can compare the risk-adjusted and the risk-unadjusted measures of breakeven inflation in terms of their ability to predict the survey expectations. To do so, I first obtain a monthly average of the two daily series and regress the survey expectations on the two measures of inflation expectations.[16] The results of these two regressions suggest that the risk-adjusted breakeven

13 It should be noted that this study has attempted to capture observable factors of liquidity and inflation risk that might drive the breakeven inflation rate. However there might be other risks that are not included in the regressions estimated in this study that may additionally explain the observed variation in the breakeven rate.

14 To ensure the positivity of the liquidity premium, the negative of the time series minimum is added to the estimated series, in line with what was done in e.g. Abrahams et al. (2016).

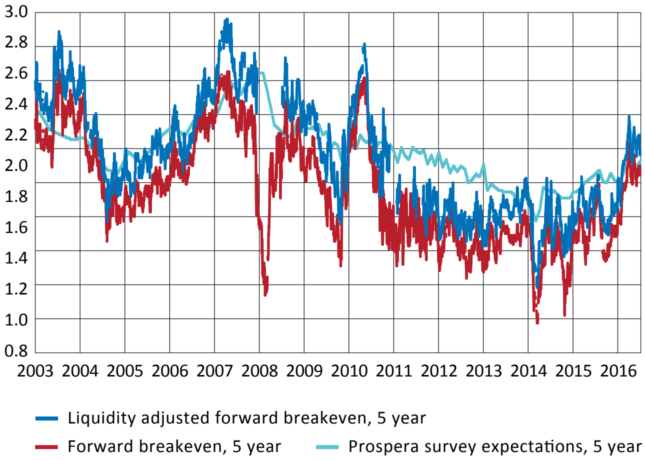
15 The estimated inflation risk premium has a mean of 0 bps and it does not seem to affect the estimation of the breakeven inflation as shown by the preferred specification (5) in Table 1.

16 The regressions are run using the same observations, which implies that the period of November 2008–April 2009 is excluded, since the adjusted breakeven lacks data for this period.

inflation outperforms the unadjusted breakeven in predicting the survey expectations. The adjusted R^2 of the regression increases from 0.56 to 0.71 when the risk-adjusted measure is used as predictor. Since the survey measure does not suffer from liquidity issues, this suggests that looking at breakeven inflation as a pure measure of inflation expectations can be misleading.

It is interesting to shed some light on the behaviour of breakeven inflation and the liquidity premium during the financial crisis. At the start of the financial crisis, the liquidity premium reached levels of 0.8 per cent (see Figure 3). At that time, there was a general worry about falling inflation expectations with breakeven inflation reaching levels of around 1.25 percent in late 2008. However, this sharp increase in the liquidity premium suggests that inflation expectations may not have fallen as low as the breakeven inflation indicates. Correcting the breakeven inflation for the high level of the liquidity premium at that time brings the inflation expectations to levels more in line with survey expectations.

Figure 4. Liquidity adjusted breakeven inflation
Per cent



Note. The gaps in the series for the liquidity adjusted breakeven are due to missing data for the fitting errors during these dates.
Sources: Sveriges Riksbank and TNS Sifo Prospera

4 Conclusion/Discussion

The aim of this PM was to estimate a measure of liquidity premium in the Swedish inflation-indexed government bond market. This was done by regressing the time series of breakeven inflation onto observable proxies of liquidity for the inflation-indexed bond market, while controlling for inflation expectations and inflation risk.

Results show that the liquidity measures are able to explain a sizeable portion of the variability in the breakeven inflation rate, suggesting the existence of a liquidity premium in the Swedish inflation-indexed government bond market. The estimated liquidity premium is positive and relatively small, with a mean of 17 bps. Moreover, the liquidity premium varies over time, depending on market liquidity conditions. It has increased during periods of heightened financial stress such as the financial crisis of 2008 and the European debt crisis. Ignoring this premium can distort the information value of the breakeven rate as a high-frequency measure of investors’ inflation expectations.

After having corrected the breakeven inflation for the liquidity premium and the presence of inflation risk we obtain a measure of inflation expectations that is more in line with the level of market participants’ inflation expectations, as measured by surveys. Compared to the survey measure, the breakeven inflation corrected for the liquidity premium has the advantage of offering a measure of inflation expectations that is available at daily frequency.

References

Abrahams, Michael, Tobias Adrian, Richard K. Crump and Emanuel Moench (2013), 'Pricing TIPS and Treasuries with Linear Regression', Staff Reports No. 570, Federal Reserve Bank of New York.

Abrahams, Michael, Tobias Adrian, T., Richard K. Crump, Emanuel Moench, and Rui Yu (2015). 'Decomposing Real and Nominal Yield Curves', *Journal of Monetary Economics*, Vol. 84 (2016), pp. 182–200.

Amihud, Yakov (2002), 'Illiquidity and stock returns: cross-section and time-series effects', *Journal of Financial Markets*, Vol. 5, No. 1, pp. 31–56.

Arvidsson, Tord, Anders Holmlund and Eric Morell (2003), 'Riksgäldskontorets marknadsvård i internationellt perspektiv', Report, Document Number 2003/307, Swedish National Debt Office.

D'Amico, Stefania, Don H. Kim and Min Wei (2014), 'Tips from TIPS: The Informational Content of Treasury Inflation-Protected Security Prices', Finance and Economics Discussion Series 2014-024, Board of Governors of the Federal Reserve.

Fontaine, Jean-Sebastien and René Garcia (2012), 'Bond liquidity premia', *Review of Financial Studies*, Vol. 25 (4), pp. 1207–1254.

Grishchenko, Olesya V. and Jing-Zhi Huang (2013), 'Inflation Risk Premium: Evidence from the TIPS Market', *Journal of Fixed Income*, Vol. 22, No. 4, pp. 5–30.

Gürkaynak, Refet S., Brian Sack and Jonathan H. Wright (2007), 'The US Treasury yield curve: 1961 to the present', *Journal of Monetary Economics,* Vol. 54, No. 8, pp. 2291–2304.

Gürkaynak, Refet S., Brian Sack and Jonathan H. Wright (2010), 'The TIPS yield curve and inflation compensation', *American Economic Journal: Macroeconomics*, Vol. 2, No. 1, pp. 70–92.

Hu, Grace Xing, Jun Pan and Jiang Wang (2013), 'Noise as Information for Illiquidity', *Journal of Finance*, Vol. 68, No. 6, pp. 2341–2382.

Kitsul, Yuriy and Jonathan H. Wright (2013), 'The economics of options-implied inflation probability density functions', *Journal of Financial Economics*, Vol. 110, No. 3, pp. 696–711.

Pflueger, Carolin E. and Luis M. Viceira (2016), 'Return predictability in the Treasury market: real rates, inflation, and liquidity', in Veronesi, Pietro (Ed.), Handbook of Fixed-Income Securities, Wiley, Hoboken, N.J., pp.191–209 (Chapter 10).

Svensson, Lars E. O. (1994), 'Estimating and Interpreting Forward Interest Rates: Sweden 1992–1994', *National Bureau of Economic Research*, Working paper No. 4871.

Söderlind, Paul (2011), 'Inflation risk premia and survey evidence on macroeconomic uncertainty', *International Journal of Central Banking*, Vol. 7, No. 2, pp. 113–132.

Wright, Jonathan H. (2011), 'Term Premia and Inflation Uncertainty: Empirical Evidence from an International Panel Dataset', *American Economic Review*, Vol. 101, No. 4, pp. 1514–34.

Appendix A

Table A1. Cross correlation between liquidity variables

Correlation	Survey inflation 5 year	Inflation risk premium	VIX	Fitting error, inflation indexed curve	Repo facility, inflation indexed	Relative transaction volume
Survey inflation 5 year	1.0000					
Inflation risk premium	−0.2084	1.0000				
VIX	0.3996	0.1217	1.0000			
Fitting error, inflation indexed curve	0.2916	0.0401	0.2493	1.0000		
Repo facility, inflation indexed	0.3128	−0.3855	−0.1391	0.0768	1.0000	
Relative transaction volume	−0.3809	0.1539	−0.0403	−0.0939	−0.1736	1.0000